Defining Falls Risk Factors in Older Adults with Cognitive Impairment Living in Residential Care

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Abstract

Introduction

Falls are common among older people and those with dementia are at higher risk of falls and injury.

In cognitively intact older people, interventions targeted at specific risk factors have proved effective at reducing falls. There is limited evidence of effective interventions for those with dementia. In order to design effective interventions for those with dementia, better understanding of risk factors is required. The aim of this study was to define falls risk factors in older people with cognitive impairment.

Methods

Participants from residential care homes underwent baseline collection of demographics and medical factors, sensorimotor, balance and gait function, behavioural and psychiatric symptoms and neuropsychological performance and were followed up for 6 months to determine faller status. Data were analysed for differences between fallers and non-fallers.

Results

Study 1 collected readily available data from 240 residential care dwellers and found 7 independent predictors of falls which were used to develop a falls risk assessment tool. These were: use of a walking frame, poor standing balance, mini mental state examination <17, use of antidepressants or hypnotic/anxiolytics, previous falls and impulsivity.

Study 2 collected detailed baseline data from 109 residential care dwellers and found 4 independent predictors of falls which were anxiety, impaired postural sway with eyes closed, poor attention and concentration and use of antidepressants.

New scales to measure physical activity and impulsivity in this population were validated and used as baseline variables. A further test to measure judgement of balance abilities was developed but did not predict faller status.

Conclusion

Two new valid and reliable scales to measure impulsivity and physical activity were developed as well as a falls risk screening tool that accurately identified those at high risk of falls. Detailed data collection identified risk factors amenable to intervention. Targeted interventions are described in the discussion.

Acknowledgments

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Finally I would like to thank my husband, mum, dad and children for supporting me throughout the last 4 years while I have worked on the thesis.

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Thesis outline

THESIS OUTLINE

Chapter 1

Chapter 1 includes a literature review covering the incidence of falls, falls risk factor studies in community, residential care dwellers and those with cognitive impairment. It also discusses interventions to prevent falls in all populations. A definition and description of dementia and cognitive impairment is provided and cognitive and non-cognitive signs and symptoms discussed in the context of how they may impact on falls risk. Finally this section includes the hypothesis, aims and objectives underlying the thesis.

Chapter 2

Chapter 2 provides detailed description of all the methods used in each of the studies. Data from a small study to assess the reliability of measures used is presented at the end of this chapter.

Chapter 3

This chapter describes the methods used and presents the results and a brief discussion for the study where readily available data were collected from 240 participants. Descriptive data is presented to provide an in-depth understanding of the study population. Differences between fallers and non-fallers and in falls rates were analysed using univariate and multivariate methods. The aim of this chapter was to produce a falls risk screening tool to be used in residential care.

Chapter 4

Chapter 4 presents the results of detailed data collection from 109 residential care dwellers with cognitive impairment. Descriptive data are presented and univarite and multivariate analysis conducted to determine which variables were associated with increased falls risk.

Chapter 5

Since no suitable physical activity scale was available to use in this study, the physical activity and mobility in residential care scale (PAM-RC) was developed and the results of the validation study presented in chapter 5.

Chapter 6

It was felt that impulsive behaviours may be important falls risk factors in this population. Since no suitable scale existed to measure this behaviour, a scale was devised and the validation study presented in chapter 6.

Chapter 7

A behavioural element which could have increased fall risk was judgement of balance ability. A test called the perceived reach test was developed to measure balance judgement and determine whether it was a useful predictor of falls. Chapter 7 provides in-depth analysis of this measure.

Chapter 8

The discussion chapter is used to summarise the findings and discuss with reference to the literature and possible reasons for these findings. This chapter is also used to develop a theoretical framework to explain falls risk in this population and develop possible interventions to be tested in future trials.

Defining Falls Risk Factors in Older Adults with Cognitive Impairment Living in Residential Care

Chapter 1

Introduction

1 Introduction

1.1 Definition of a fall

For the purpose of the thesis, a fall is defined as "an unexpected event in which the participant comes to rest on the ground, floor or lower level"(Lamb et al., 2005).

1.2 The incidence of falls in community dwelling populations

Some of the earliest research into falls in older people in the 1970s and 1980s provided data on the proportion of older people likely to experience a fall each year. Exton-Smith and colleagues in 1977 found 30% women and 13% men aged 65-69 fell within a one year period (Exton-Smith, 1977). The proportion increased in those aged >85, to 50% in women and 30% in men. Several studies followed this which set the widely accepted figure of 30% of those aged over 65 sustaining a fall each year found in cohorts throughout the western world (Campbell et al., 1981, Prudham and Evans, 1981, Tinetti et al., 1988a, Blake et al., 1988, O'Loughlin et al., 1993, Lord et al., 1994b). Table 1.1 provides an overview of the studies reporting the incidence of falls. Rubenstein (2006) provided pooled incidence rates for falls in community dwellers from published studies and suggested that community dwelling people aged >65 have an incidence of 0.65 (95%CI 0.3-1.8) falls per person per year with that figure doubling in those aged >75 (Rubenstein, 2006).

Table 1.1 Incidence of falls in community dwellers

(Author, year)	Population Age and location	N	Proportion of fallers*
(Exton-Smith, 1977)	>65 UK	963	Women 65-69 = 30% >85 = 50% Men 65-69 = 13% >85 = 30%
(Campbell et al., 1981)	>65 New Zealand	533	33%
(Prudham and Evans, 1981)	>65	2793	28%
(Blake et al., 1988)	>65 UK	1042	35%
(Tinetti et al., 1988a)	>75 USA	336	32%
(Campbell et al., 1989)	>70 New Zealand	761	Women = 40% Men = 28%
(Lord et al., 1994b)	Women >65	341	39%
(O'Loughlin et al., 1993)	>65 Canada	409	29%
(Lord et al., 1994a)	>60 Australia	1762	28%
(Luukinen et al., 1995b)	>70 Finland	833	30%
(Graafmans et al., 1996)	>70 Supported housing Netherlands	354	36% (in 28 weeks)
(Tromp et al., 1998)	>65 Netherlands	1285	33%
(Rubenstein, 2006)	*Meta-analysis*		Mean 0.65 PPPY (0.3-1.6)

* Per year unless stated otherwise

1.3 The incidence of fall related injuries in community dwelling populations

The problem of falls lies not just in the frequency. Young children and athletes have higher fall rates than older people however their susceptibility to injury is lower.

The reporting of falls related injuries varies widely with between 10 and 30% of falls resulting in an injury (Tinetti et al., 1988a, Stevens et al., 2008). The majority of injuries are considered minor and involve bruises, cuts and abrasions. Fractures occur in around 5% of falls (Rubenstein, 2006). Fractures of the radius and ulna are common at the stage when postural stability declines enough for a fall to occur but intact upper limb saving reactions mean the outstretched arm takes the force of the fall. Hip fracture occurs in up to 2% of falls as reaction times decline to the extent that upper limb reactions no longer precede the fall.

Sustaining a hip fracture has serious consequences. Marottoli found that of those living at home who suffered a hip fracture 18% had died and 29% were institutionalised within 6 months of fracture (Marottoli et al., 1994). The same study looked at reported function before and 6 months after the fracture. Before the hip fracture, 86% could dress, 90% transfer, 75% walk across a room, 63% climb a flight of stairs and 41% walk half a mile independently. Six months after the hip fracture only 49% could dress, 32% transfer, 15% walk across a room, 8% climb stairs and 6% walk half a mile independently (Marottoli et al., 1992).

Overall, fall related injury contributes significantly to health care use. One study looking at Medicare use in the United States estimated that 2.2 million people suffered a medically injurious fall in 2002 (Shumway-Cook et al., 2009). In 2004, falls in those aged over 60 living in the UK resulted in 17,157 138 disability adjusted life years (WHO, 2008). The World Health Organisation (WHO) reported falls related hospitalisations ranging from 1.6-3.0 and emergency department visits from 5.5-8.9 per 10,000 population aged over 60 (WHO, 2007). This range of figures may reflect differences in health care provision and reporting globally as in the UK in 1999 Scuffham found a hospital admission rate of 34.5 per 10,000 population in those aged 60-64 rising to 368.6 per 10,000 for those aged 75 or more. The rate for emergency department visits were also much higher ranging from 273.5/10,000 in those aged 60-64 to 945.3/10,000 in those 75 or more (Scuffham et al., 2003). In Canada, falls were found to contribute to 10-15% of emergency department visits and more than 50% of injury related hospital admissions in those aged >65 (Scott and Gallagher, 1999).

In a very small proportion of cases, falls result in death. Each year there are 424,000 fall related deaths in all age groups with those aged >60 having the highest death rates (WHO,

2010). This is likely to underestimate the true cost of falls as secondary complications of falls resulting in death will not be recorded in these statistics.

1.4 Definition of residential care

The term residential care is defined as an institution where care (supervision, personal or nursing care) is present and available on a 24 hour basis. In the United Kingdom this includes care homes with and without nursing care.

1.5 The incidence of falls in residential care

The incidence of falls in residential care is significantly higher than that of community dwellers. Around 50% of this population is likely to fall each year (Lord et al., 2003a, Thapa et al., 1996a, Luukinen et al., 1995c). The incidence has been reported as 1.5 -1.7 falls per bed per year (Luukinen et al., 1995a, Rubenstein, 2006) or 1.4 falls per person per year (Nurmi and Luthje, 2002) (Table 1.2).

1.6 The incidence of fall related injuries in residential care

Injury occurs in around one third and hospitalisation is required in one fifth of falls in this setting (Nurmi and Luthje, 2002). Luukinen et al found fracture rates in community dwelling men of 12 and women of 33/1000 person years while men and women living in institutions had a fracture rate of 33 and 41/1000 person years respectively (Luukinen et al., 1995a).

Table 1.2 Incidence of falls in residential care

(Author, year)	Population Age and location	N	Proportion of fallers*
(Luukinen et al., 1994)	>70 Finland	145	43% ≥2 falls
(Nurmi and Luthje, 2002)	>60 Ambulatory	1056	27%
(Rubenstein, 2006)			Mean 1.7 falls PPPY (0.6-3.6)
(Thapa et al., 1996a)	>65 USA	1228	45%
(Gibson et al., 2008)	Australia	28536 bed months	171 falls per 100 bed days (2 PPPY)
(Lord et al., 2003a)	Nursing home Hostel >65 Australia	1000	65% hostel 58% NH 5.45 falls per 1000 bed days

*per year unless otherwise indicated. PPPY=per person per year.

Hip fracture is also a serious problem for those living in residential care. While only 4 % of the UK population aged >65 live in residential care, 20% of UK hip fracture admissions come from this group (Morgan et al., 2004). Hip fracture rates in residential care ranging from 54/1000 person years (Nurmi and Luthje, 2002) to 4% per person per year (Chen et al., 2009) have been reported. Gibson et al found that 40% of fall related hospitalisations in this group were for hip fracture and only 30% of those who sustained a hip fracture were alive 3 months later (Gibson et al., 2008). Similarly, Berry et al found that during the mean follow up of 1.4 years of nursing home residents who sustained a hip fracture, 77% died within this period (Berry et al., 2009).

Those who sustain a hip fracture while living in residential care tend have a shorter length of stay in hospital, but have significantly reduced recovery of mobility. Burleigh and colleagues found that of those who could mobilise unaided prior to a hip fracture, 56% of those discharged back to their own home returned to this function after 120 days compared to 22% of those returning to a residential care home. Also, 63% of those returning home walked with a walking aid at discharge compared to 28% care home residents. Additionally, those living

in care homes were significantly less likely to get a fall and fracture risk assessment while in hospital (Burleigh et al., 2011).

1.7 The burden of falls on the individual and the economy

In addition to fall related injury, there are many other consequences of falls.

Nearly half of all fallers are unable to get up from the floor independently following a fall (Tinetti et al., 1993). In the absence of help, this may lead to a long lie. A long lie has been defined as remaining on the ground for more than 1 hour (Lord et al., 2007). A long duration spent on the floor may lead to hypothermia, pneumonia and muscle tissue damage and Wild et al found that within 6 months, half of those who had suffered a long lie had died (Wild et al., 1981).

The post fall syndrome has been described as loss of self-confidence and fear of falling following a fall (Murphy and Isaacs, 1982). This fear and loss of confidence manifests as restriction of activity which results in progression of muscle weakness, worsening balance and reduction in functional abilities, increasing fall risk.

The economic burden of falls on health and social care systems is difficult to fully estimate as many falls are not reported and subsequent costs from physical decline related to post fall syndrome not measured. Scuffham looked at health and social care costs resulting from falls in those aged >60 in the UK in 1999 and found that the total cost of falls in one year in this population was £981million. The costs were split almost equally between health and social care with the majority of spending on hospitalisations and long term care (Scuffham et al., 2003). Stevens looked at fatal and non-fatal falls in the US at a similar time (2000). In this year there were 10,300 fatal falls and 2.6m medically treated non-fatal falls in those aged 65

and over. Non-fatal falls cost $19billion to treat with most (63%) spent on hospitalisation or emergency room visits (21%). In this study fractures only represented 35% of the injuries but amounted to 61% of the costs (Stevens et al., 2006).

There have been two recent systematic reviews examining the cost of falls. Davis et al calculated the cost in US$ and found using 2008 prices, the mean cost of a faller was $3,476 rising to $10,749 for an injurious fall and $26,483 for a fall requiring hospitalisation (Davis et al., 2010). Comparably, Henrich used 2006 prices and found costs ranged from US$2,004-25,955 per faller, $1,059-10,913 per fall and $5,654-42,840 per fall related hospitalisation. They estimated that falls costs equated to between 0.85-1.5% of total health expenditure and 0.07-0.20% of gross domestic product of the countries where economic data had been published and used in their review (Heinrich et al., 2010). Tiedemann and colleagues emphasised the cost of fall related hospitalisations. In their 2008 study they found that 67% of fall related costs were spent on hospitalisations when only 4% of the population required hospital admission (Tiedemann et al., 2008b). In this group, the mean cost in AUS$ per fall was $1,600. Most of the costs of falls have not discriminated between place of residence however, one study estimated that each fall in a care home resident cost €944 (Nurmi and Luthje, 2002).

1.8 Risk factors for falls

Falls are not random events, the presence or absence of certain factors increase the likelihood of sustaining a fall. These factors are known as risk factors for falls. Since the late 1980s more than 100 papers have examined falls and fall related fracture risk factors. In this review, risk factors for community dwellers and care home dwellers will be discussed separately to illustrate the similarities and differences between the two groups. The risk factors in care

homes are most relevant to this study but more work has been carried out on community dwellers providing a good basis for the understanding of relevant risk factors.

Work has been done to investigate risk factors for single falls, multiple (more than one) falls, injurious falls and fall related fractures.

Fall risk factors can be identified in two different ways. Retrospective studies measure variables and compare those who report falling to those who report no falls in a specified period prior to measurement. Case control studies also measure previous falls but the study is specifically designed to recruit fallers and non-fallers in equal numbers, sometimes matched for age or sex. The limitations of these studies are that falls are often poorly recalled (Lord et al., 2007) so some of those claiming to be non-fallers, may in fact have fallen. Also as the fall has already occurred, the differences between groups may be due to injuries or other consequences of falling rather than being a true risk factor. Prospective studies undertake measurement of potential risk factors and follow participants to determine subsequent faller status and falls rates. This is usually done with self-report using a falls diary. Prospective studies are seen to be the gold standard for identification of risk factors. However, self-report has its limitations in that those with cognitive impairment may not remember to report all falls. This is overcome if responsible carers can provide accurate reports, more so if this is part of a structured reporting system.

1.8.1 Risk factors for falls in community dwellers

Falls risk factors have been identified in several domains in community dwelling populations including; sensorimotor, gait and balance function, functional ability, medical conditions, medication and psychological issues. Detailed discussion of risk factors relating to cognition will be discussed in a separate section.

1.8.1.1 Sensorimotor risk factors for falls

Impaired vision, sensation, reaction times and muscle strength have all been identified as risk factors for falls and fall related injuries.

1.8.1.1.1 Vision

Impaired visual acuity is one of the most commonly identified visual risk factors. Visual acuity is one of the simplest measures of vision and is likely to have been more frequently measured in risk factor studies than more complex tests of different visual functions. Vision contributes to sensory input required to control postural stability and facilitates safe and effective negotiation of the environment. To identify potential trip hazards such as obstacles or changes in surface heights, adequate contrast sensitivity and depth perception are required. Both depth perception and contrast sensitivity have been consistently identified as falls risk factors (Nevitt et al., 1989, Lord and Dayhew, 2001, Lord et al., 1991c, Lord et al., 1994b). In fact, when contrast sensitivity and depth perception were measured as well as visual acuity, the former two better predicted faller status (Lord and Dayhew, 2001) (Table 1.3).

1.8.1.1.2 Sensation

Peripheral sensation, particularly in the lower limbs contributes to afferent inputs that control postural stability. Different measurements of sensation include tactile sensitivity, proprioception and vibration sense. All of these functions have been found to be worse in those who fall (Lord et al., 1994b, Lord et al., 1991b, Lord et al., 1992) or fracture (Lord et al., 1994a) (Table 1.3).

Table 1.3 Studies where impaired sensory function was found to be significantly associated with falls outcomes in univariate or multivariate analysis

Domain	Variables	Any fall	Multiple falls*	Fall injury / fracture
Vision	**Depth perception**		(Nevitt et al., 1989)a, (Lord and Dayhew, 2001)a	(Ivers et al., 2000)b, (Cummings et al., 1995)a
	Contrast sensitivity	(Lord and Fitzpatrick, 2001)b	(de Boer et al., 2004)a, (Lord and Dayhew, 2001)a, (Lord et al., 1991a)a, (Lord et al., 1994b)a, (Ivers et al., 1998)b,	(Cummings et al., 1995)a
	Low contrast visual acuity		(Lord and Dayhew, 2001)a, (Lord et al., 1994b)a, (Tiedemann et al., 2010)a	
	Visual acuity	(Lord et al., 1999)b	(Nevitt et al., 1989)a, (Ivers et al., 1998)b, (Klein et al., 2003)a,	(Dargent-Molina et al., 1996a)a, (Ivers et al., 2000)b, (Felson et al., 1989)a, (Klein et al., 2003)a,
	Visual fields		(Ivers et al., 1998)b,	(Patino et al., 2010)a
	Visual sensitivity		(Klein et al., 2003)a,	(Klein et al., 2003)a,
	Near vision	(Tinetti et al., 1988b)a		(Klein et al., 2003)a,
	Poor vision (reported)	(Lord et al., 1993)b, (Yasumura et al., 1994)b		
	Recognising faces		(de Boer et al., 2004)a	
Sensation	**Proprioception**	(Lord and Fitzpatrick, 2001)b, (Lord et al., 1999)b	(Lord et al., 1994b)a, (Lord et al., 1991a)a	
	Vibration sense		(Lord et al., 1994b)a,	
	Tactile sensitivity	(Lord and Clark, 1996)a	(Lord et al., 1992)b, (Lord et al., 1994a)b, (Tiedemann et al., 2010)a	(Lord et al., 1992)b (Lord et al., 1994a)b
	Plantar sensitivity	(Menz et al., 2006)a		
Vestibular	**Asymmetry**			(Kristinsdottir et al., 2001)b, (Kristinsdottir et al., 2000)b
	Failure to suppress VOR	(Di Fabio et al., 2002)b		
	Greater visual dependence	(Lord and Webster, 1990)b	(Lord et al., 1994a)b	

a=prospective study, b=retrospective / case control * More than 1 fall

1.8.1.1.3 Vestibular function

Very few studies have identified impairments in vestibular function to be associated with increased falls risk (Lord et al., 2007) although dizziness is common in people who fall (O'Loughlin et al., 1993, Luukinen et al., 1996). It is likely that vestibular impairment is associated with increased fall risk, but that mild uncompensated vestibular dysfunction cannot be easily measured and therefore the association has not been found yet.

1.8.1.1.4 Reaction times

Slower reaction times are associated with increased falls risk (Lord et al., 1991b, Lord et al., 1994b, Lord and Fitzpatrick, 2001, Dhesi et al., 2002). Slow responses to balance perturbations and correction of trips or slips mean that when postural stability is threatened, a fall is less likely to be avoided (Lord et al., 2007). Simple reaction times are the time taken to respond to a single stimulus with a single response. Where there is more than one stimulus or possible response, this is defined as a choice reaction time. Simple reaction times are easier to measure but choice reaction times may identify more subtle deficits which are relevant to the everyday functional requirements of maintaining postural stability (Table 1.4).

Table 1.4 Studies where slow reaction times were found to be significantly associated with falls outcomes in univariate or multivariate analysis

Variables	Any fall	Multiple falls*	Fall injury / fracture
Simple reaction times	(Grabiner and Jahnigen, 1992)b, (Lord and Clark, 1996)a,	(Lord et al., 1994b)a, (Lord et al., 1991a)a,	(Adelsberg et al., 1989)b
Choice reaction times	(Lord and Fitzpatrick, 2001)b, (Dhesi et al., 2002)b, (Woolley et al., 1997)b		

a=prospective study, b=retrospective / case control * More than 1 fall

1.8.1.1.5 Muscle strength and power

Muscle weakness has consistently been identified as a risk factor for falls (Moreland et al., 2004). Most studies have concentrated on lower limb muscle groups as these are likely to be more important in maintaining an upright posture. Where muscle power has been measured, it has been worse in fallers (Skelton et al., 2002), although due to measurement complexity has been studied less often (Table 1.5).

Table 1.5 Studies where muscle weakness was found to be significantly associated with falls outcomes in univariate or multivariate analysis

Variables	Any fall	Multiple falls*	Fall injury / fracture
Knee strength	(Lord and Clark, 1996)a, (Takazawa et al., 2003)a, (Dhesi et al., 2002)b, (Lord et al., 1999)b	(Lord et al., 1994b)a, (Lord et al., 1994a)b, (Stel et al., 2003)a, (Takazawa et al., 2003)a	(Lord et al., 1992)b (Lord et al., 1994a)b, (Nguyen et al., 1993)a
Ankle strength		(Takazawa et al., 2003)a, (Lord et al., 1994b)a, (Lord et al., 1991a)a	
Grip strength	(Campbell et al., 1989)a, (Blake et al., 1988)b	(Stel et al., 2003)a	
Muscle power		(Skelton et al., 2002)b	
Muscle endurance	(Schwendner et al., 1997)b		
Foot strength	(Menz et al., 2006)a		

a=prospective study, b=retrospective / case control * More than 1 fall

1.8.1.2 Balance and gait related risk factors

Several different methods of measuring balance have identified differences in performance between fallers and non-fallers. Fallers have larger dimensions of sway area in static standing with or without vision (Lord et al., 1991b, Lord et al., 1992, Lord et al., 1994b, Lord et al., 1994a), have decreased leaning balance ability (Duncan et al., 1992, Menz and Lord, 2001, Sturnieks et al., 2004, Butler et al., 2011) and have worse function when asked to stand in

positions that challenge balance such as near tandem standing (Tiedemann et al., 2010, Stel et al., 2003, Lord et al., 1999) (Table 1.6).

Table 1.6 Studies where impaired balance was found to be significantly associated with falls outcomes in univariate or multivariate analysis

Variables	Any fall	Multiple falls*	Fall injury / fracture
Sway	(Overstall et al., 1977)b, (Cho and Kamen, 1998)b, (Lord and Clark, 1996)a, (Campbell et al., 1989)a	(Lord et al., 1991a)a, (Lord et al., 1994b)a, (Lord et al., 1994a)b,	(Lord et al., 1992)b (Lord et al., 1994a)b
Lateral stability	(Maki et al., 1994)a, (Lord et al., 1999)b	(Stel et al., 2003)a	
Static balance	(Woolley et al., 1997)b,		
Rhomberg	(Cho and Kamen, 1998)b,		
Tandem / near tandem stand	(Heitmann et al., 1989)b, (Lord et al., 1999)b	(Stel et al., 2003)a, (Tiedemann et al., 2010)a	
Unsteady sitting down	(Tinetti et al., 1988b)a		
Unsteady with external push	(Tinetti et al., 1988a)a		
Leaning balance	(Butler et al., 2011)a, (Muir et al., 2010)a, (Menz and Lord, 2001)b, (Sturnieks et al., 2004)b	(Duncan et al., 1992)a	
POMA	(Tinetti et al., 1988b)a, (Chiu et al., 2003)b	(Tinetti et al., 1986)a, (Chiu et al., 2003)b	(Tinetti et al., 1995a)a, (Koski et al., 1996)a
Berg balance scale	(Chiu et al., 2003)b, (Bogle Thorbahn and Newton, 1996)a, (Shumway-Cook et al., 1997a)b	(Chiu et al., 2003)b, (Berg et al., 1992)a	
Stepping	(Dite and Temple, 2002)b, (Cho and Kamen, 1998)b	(Dite and Temple, 2002)b, (Tiedemann et al., 2010)a	
Single leg stance	(Muir et al., 2010)a, (Studenski et al., 1991)b, (Hurvitz et al., 2000)b		(Muir et al., 2010)a, (Vellas et al., 1998)a

a=prospective study, b=retrospective / case control * More than 1 fall

Several balance scales have combined different balance and gait functions to provide a more comprehensive and functional measure of postural stability. The Berg balance scale and performance orientated mobility assessment (POMA) both demonstrate significant differences between fallers and non-fallers (Berg et al., 1992, Shumway-Cook et al., 1997a, Tinetti et al., 1988a). The timed up and go combines measurement of gait speed, standing up, sitting down and turning and differences between fallers and non-fallers are apparent, with fallers taking longer to complete the test (Shumway-Cook et al., 2000, Rose et al., 2002, Gunter et al., 2000).

Many gait parameters are difficult to measure without specialist equipment but studies that have used such equipment have found that fallers have more gait variability (Maki, 1997, Hausdorff et al., 2001, Lord et al., 1996) and longer double support duration (Lord et al., 1996, Nelson et al., 1999, Maki, 1997, Mbourou et al., 2003). Gait speed can be measured simply and fallers have significantly slower speeds (Campbell et al., 1989, Luukinen et al., 1995a, Maki, 1997, Nelson et al., 1999) (Table 1.7). The slowing of gait may be a reflection of poor postural stability as a result or muscle weakness and/or slow reaction times resulting in a compensatory slower gait which is less destabilising. This has been described as a "conservative gait pattern"(Lord et al., 2007).

Table 1.7 Studies where gait impairment was found to be significantly associated with falls outcomes in univariate or multivariate analysis

Variables	Any fall	Multiple falls*	Fall injury / fracture
Tandem walk	(Gunter et al., 2000)b	(Nevitt et al., 1989)a	(Dargent-Molina et al., 1996b)a
Timed up and go	(Chiu et al., 2003)b, (Gunter et al., 2000)b	(Chiu et al., 2003)b, (Dite and Temple, 2002)b, (Shumway-Cook et al., 2000)b, (Rose et al., 2002)b, (Gunter et al., 2000)b	
Walking speed	(Guimaraes and Isaacs, 1980)b, (Woo et al., 1995)b, (Ho et al., 1996)b, (Woolley et al., 1997)b, (Nelson et al., 1999)b, (Campbell et al., 1989)a, (Maki, 1997)a, (Cho and Kamen, 1998)b	(Luukinen et al., 1995b)a	(Dargent-Molina et al., 1996b)a
Reduced stride / step length	(Guimaraes and Isaacs, 1980)b, (Woo et al., 1995)b, (Mbourou et al., 2003)b		
Step variability	(Guimaraes and Isaacs, 1980)b, (Maki, 1997)a, (Hausdorff et al., 2001)a, (Mbourou et al., 2003)b	(Lord et al., 1996)a	
Double support duration	(Nelson et al., 1999)b, (Maki, 1997)a, (Mbourou et al., 2003)b	(Hill et al., 1999)a, (Lord et al., 1996)a	
Dynamic gait index	(Whitney et al., 2000)b		

a=prospective study, b=retrospective / case control * More than 1 fall

1.8.1.3 Functional ability and physical activity

Those who are less independent in activities of daily living (Tinetti et al., 1988a, Prudham and Evans, 1981), walking (O'Loughlin et al., 1993, Tromp et al., 1998), standing up from sitting (Campbell et al., 1989, Nevitt et al., 1989) and those who use walking aids (Tinetti et al., 1988a) have a greater risk of falls(Table 1.8). Low levels of physical activity are also

associated with increased risk (Campbell et al., 1989, O'Loughlin et al., 1993, Peeters et al., 2010). However, this relationship is complicated. Those with very low levels of activity have a theoretically higher risk of falls as they lose muscle strength, power, balance and gait skills. On the other hand, the less time spent standing upright, the lower their exposure to falling (O'Loughlin et al., 1993). This has led to findings of non-linear patterns where those with the highest and lowest function and activity levels have the fewest falls and the intermediate group are at highest risk.

Table 1.8 Studies where functional impairment was found to be significantly associated with falls outcomes in univariate or multivariate analysis

Function	Any fall	Multiple falls*	Fall injury / fracture
Activities of daily living	(von Heideken Wagert et al., 2009)a, (Davis et al., 1999)a, (Ho et al., 1996)b, (Prudham and Evans, 1981)b, (Tinetti et al., 1988b)a		
Walking ability	(O'Loughlin et al., 1993)a, (Prudham and Evans, 1981)b	(Tromp et al., 1998)a	
Sit to stand ability	(Davis et al., 1999)a, (Campbell et al., 1989)a	(Nevitt et al., 1989)a, (Tiedemann et al., 2010)a	(Davis et al., 1999)a
Bending down	(O'Loughlin et al., 1993)a		
Stairs	(Woolley et al., 1997)b		
Physical activity	(O'Loughlin et al., 1993)a, (Ho et al., 1996)b, (Campbell et al., 1989)a, (Schwartz et al., 1999)a	(Peeters et al., 2010)a	(Tromp et al., 1998)a
Walking aid	(Tinetti et al., 1988a)a		

a=prospective study, b=retrospective / case control * More than 1 fall

1.8.1.4 Medical conditions

Medical conditions associated with high risk of falls include depression, Parkinson's disease, cataracts, glaucoma, orthostatic hypotension, stroke, arthritis, foot problems, peripheral neuropathy and incontinence (Table 1.9).

Table 1.9 Studies where medical conditions were found to be significantly associated with falls outcomes in univariate or multivariate analysis

Medical conditions	Any fall	Multiple falls*	Fall injury / fracture
Cancer			(Herndon et al., 1997)b
Anaemia			(Herndon et al., 1997)b
Diabetes			(Malmivaara et al., 1993)b, (Herndon et al., 1997)b (Ivers et al., 2001)a
Thyroid dysfunction	(von Heideken Wagert et al., 2009)a, (Schwartz et al., 1999)a		
Depression	(Tinetti et al., 1988a)a, (Kutner et al., 1994)b, (Whooley et al., 1999)a	(Nevitt et al., 1989)a, (Lawlor et al., 2003)b	(Whooley et al., 1999)a
Parkinson's disease	(Dolinis et al., 1997)b	(Nevitt et al., 1989)a	(Herndon et al., 1997)b
Cataracts		(Ivers et al., 1998)b	(Herndon et al., 1997)b (Ivers et al., 2003)a
Glaucoma	(Dolinis et al., 1997)b		(Herndon et al., 1997)b
Hypertension			(Herndon et al., 1997)b
Orthostatic hypotension	(Gabell et al., 1985)a, (Heitterachi et al., 2002)a	(Luukinen et al., 1996)a	
Heart disease	(Prudham and Evans, 1981)b	(Lawlor et al., 2003)b	(Herndon et al., 1997)b
Stroke	(Dolinis et al., 1997)a, (Prudham and Evans, 1981)b, (Jorgensen et al., 2002)a, (Yasumura et al., 1994)b, (Campbell et al., 1989)b		(Herndon et al., 1997)b, (O'Loughlin et al., 1993)a
White matter /SCV lesions	(Guerini et al., 2008)a, (Srikanth et al.,		

Medical conditions	Any fall	Multiple falls*	Fall injury / fracture
	2009)a		
Dizziness	(O'Loughlin et al., 1993)a, (Prudham and Evans, 1981)b, (Blake et al., 1988)b	(Luukinen et al., 1996)a	
COPD		(Lawlor et al., 2003)b	(Herndon et al., 1997)b
Arthritis	(Dolinis et al., 1997)b, (Sturnieks et al., 2004)b, (Campbell et al., 1989)a, (Schwartz et al., 1999)a, (Blake et al., 1988)b, (Torgerson et al., 1993)b	(Nevitt et al., 1989)a, (Lawlor et al., 2003)b	(Sturnieks et al., 2004)b
Foot problems	(Dolinis et al., 1997)b, (Gabell et al., 1985)a, (Tinetti et al., 1988b)a, (Menz et al., 2006)a, (Blake et al., 1988)b		
Peripheral neuropathy	(Richardson and Hurvitz, 1995)b,	(Luukinen et al., 1995b)a	(Cavanagh et al., 1992)b
Incontinence	(Tinetti et al., 1988a)a, (Yasumura et al., 1994)b, (Brown et al., 2000)a	(Nevitt et al., 1989)a, (Luukinen et al., 1996)a, (Tromp et al., 1998)a	(Brown et al., 2000)a
Previous hip #	(Dolinis et al., 1997)b		
Previous other #			(Vellas et al., 1998)a, (Nevitt et al., 1991)a (Tromp et al., 1998)a
Previous falls	(Tinetti et al., 1988a)a, (Davis et al., 1999)a	(Luukinen et al., 1996)a, (Luukinen et al., 1995b)a, (Tiedemann et al., 2010)a	

a=prospective study, b=retrospective / case control * More than 1 fall

1.8.1.4.1 Depression

Depression is common in older people with an estimated 25% of those aged >65 suffering symptoms (Craig and Mindall, 2007) and it is difficult to determine why people with depression are more likely to fall. Being depressed is associated with known risk factors such as physical inactivity and functional impairment (Whooley et al., 1999). Additionally, use of

antidepressant medication is associated with falls and it is difficult to disentangle which of the two is the most important factor in two very closely linked risk factors.

1.8.1.4.2 Parkinson's disease

The proportion of those with Parkinson's disease (PD) who fall is higher than that of the general population with 64-68% of people with PD falling each year (Wood et al., 2002, Ashburn et al., 2001). PD symptoms include tremor, bradykinesia, rigidity and postural instability all of which could increase susceptibility to falling. People with Parkinson's disease are also more likely to be depressed and develop dementia. Other possible causes include specific antiparkinsonian medications or autonomic dysfunction. A recent study found that a combination of Parkinsonian symptoms, freezing of gait and orthostatic hypotension were all significant predictors of future falls in a logistic regression model (Kerr et al., 2010).

1.8.1.4.3 Cataracts and glaucoma

Cataracts and glaucoma both impair vision. Impaired visual acuity, contrast sensitivity and depth perception, all caused by such eye diseases have already been discussed as fall risk factors. One study found that medication used to treat Glaucoma was associated with an increased risk of falls for a period after application (Ivers et al., 1998).

1.8.1.4.4 Syncope

Orthostatic hypotension

Orthostatic hypotension (OH) is defined as drop of ≥20mmHg in systolic blood pressure on standing up from the supine position (Moya et al., 2009). The drop in blood pressure associated with standing up can cause symptoms such as dizziness, light-headedness or even syncope. Around 12% cases of syncope are due to OH (Mussi et al., 2009). Amnesia for loss

of consciousness is common (Parry et al., 2005) and therefore many presentations or reports of falls may be due to syncope. On the other hand, merely the light-headedness caused by OH in a person with poor postural stability may be enough to cause a fall.

Carotid sinus syndrome

Carotid sinus syndrome may present as a cardioinhibitory form, a vasodilator form or a mixed form. Among fallers attending an accident and emergency department, 20% had unexplained falls and a third of these had carotid sinus hypersensitivity (Kenny et al., 2001, Puggioni et al., 2002). It is caused by accidental manipulation of the carotid sinuses and can be diagnosed using carotid sinus massage. A positive response to this is a ventricular pause of ≥3 seconds and/or a fall in systolic BP ≥50mmHg (Brignole, 2006).

Vasovagal syncope

Vasovagal syncope occurs as a result of reflex mediated vasodilation and/or bradycardia. Classical vasovagal syncope is preceded by an orthostatic or emotional trigger and is less common in older people. Non-classical vasovagal syncope does not necessarily result from any trigger and may be related to antihypertensive medication (Brignole, 2006).

1.8.1.4.5 Stroke

Stroke, like Parkinson's disease can result in increased prevalence of known risk factors. Muscle weakness, sensory and perceptual impairment and cognitive dysfunction are common consequences of stroke. The proportion of those who fall in the 6 months following stroke is as high as 73% (Batchelor et al., 2012).

1.8.1.4.6 Arthritis

Arthritis is consistently found to increase risk of falls (Nevitt et al., 1989, Campbell et al., 1989, Blake et al., 1988, Sturnieks et al., 2004). Arthritis particularly of the lower limbs

results in muscle weakness, proprioceptive (Pai et al., 1997) and balance dysfunction (Hinman et al., 2002) and functional impairment (Hurley et al., 1997), all known risk factors for falls. Pain and loss of joint flexibility may also contribute to increased falls risk (Whipple et al., 1993). There is evidence that falls risk is increased in both osteoarthritis (Granek et al., 1987, Nevitt et al., 1989) and rheumatoid arthritis (Hayashibara et al., 2010, Stanmore et al., 2013).

1.8.1.4.7 Foot problems

Foot problems are common in older people and have many possible causes. The foot is the interface between the environment and the person and therefore any impairment that affects muscle function, range of movement and sensation in the foot is likely to cause balance and gait impairments and in turn increase the risk of falls (Tinetti et al., 1988a, Blake et al., 1988, Menz et al., 2006).

1.8.1.4.8 Peripheral neuropathy

Peripheral neuropathy has been associated with increased risk of falls (Luukinen et al., 1995b). Peripheral neuropathy affects tactile sensation, proprioception and vibration sense, already known fall risk factors.

1.8.1.4.9 Incontinence

There is debate as to why urinary incontinence is such a prevalent falls risk factor (Nevitt et al., 1989, Tromp et al., 1998) as unlike other bodily functions discussed, continence does not directly influence postural stability. It may be that the fear of incontinence causes people to fall as they are rushing to get to the toilet. However another explanation is that incontinence is a marker of physical frailty where the resultant muscle weakness, functional impairment

and slow gait speed increases the risk of falls. The main types of urinary incontinence experienced in older people are stress and urge incontinence. Stress incontinence is diagnosed when a small amount of urine is lost when abdominal pressure is raised (when coughing, sneezing or engaging in physical activity). Urge incontinence is a result of detrusor muscle instability where the detrusor muscle may contract when voluntary voiding has not been initiated. This can result in urgency as well as incomplete bladder emptying. Incontinence in older people may also reflect poor mobility delaying getting to a toilet, poor dexterity causing difficulty with removing clothing before voiding or cognitive impairment limiting the awareness of the need to void (Chiarelli et al., 2009).

1.8.1.4.10 Previous falls and fractures

One of the best ways to predict future falls is to look at the history of previous falls and fall related fractures. This is such a strong indicator of future falls that evidence based falls prevention guidelines have used a fall to trigger further assessment and falls prevention interventions (Panel on Prevention of Falls in Older Persons and British Geriatrics, 2011).

1.8.1.5 Medication related falls risk factors

Medications are thought to affect falls in two ways; firstly drugs that affect central nervous system processing speeds may cause slow reaction times, balance and coordination difficulties and confusion. Secondly, drugs that affect the cardiovascular system increase the likelihood of orthostatic hypotension (Table 1.10).

Table 1.10 Studies where specified medications were found to be significantly associated with falls outcomes in univariate or multivariate analysis

Medication	Any fall	Multiple falls*	Fall injury / fracture
CNS (any type)	(Weiner et al., 1998)a	(Hanlon et al., 2009)a,	
Psychotropic (any type)	(Campbell et al., 1989)a, (Prudham and Evans, 1981)b, (Tinetti et al., 1988a)a, (Schwartz et al., 1999)a, (Vitry et al., 2010)a	(Berdot et al., 2009)a, (Tromp et al., 1998)a, (Luukinen et al., 1995b)a	(Vitry et al., 2010)a
Benzodiazepines	(Blake et al., 1988)b, (Ebly et al., 1997)b (Masud et al., 2013)b	(Berdot et al., 2009)a, (Rossat et al., 2011)a, (Cumming et al., 1991)b, (Lawlor et al., 2003)b, (Lord et al., 1995)a	(Ryynanen et al., 1993)b, (Neutel et al., 1996)a (Ray et al., 1987)b, (Herings et al., 1995)b
Antidepressants (any type)	(Blake et al., 1988)b, (Ebly et al., 1997)b, (Svensson et al., 1992)b (Masud et al., 2013)b	(Kerse et al., 2008a)b, (Lawlor et al., 2003)b, (Lord et al., 1995)a	(Ray et al., 1987)b, (Ensrud et al., 2002)a, (Ray et al., 1991)b
SSRIs	(von Heideken Wagert et al., 2009)a	(Kerse et al., 2008a)b	(Richards et al., 2007)a
Antipsychotics			(Ray et al., 1987)b
Analgesics (any type)	(Masud et al., 2013)b		(Tromp et al., 1998)a
Opiates	(Masud et al., 2013)b		(Vestergaard et al., 2006)b
NSAIDS			(Koski et al., 1998)a
Diuretics / antihypertensives (any type)	(Gribbin et al., 2010)b, (Prudham and Evans, 1981)b, (Campbell et al., 1989)a, (Torgerson et al., 1993)b	(Cumming et al., 1991)b	(Koski et al., 1998)a
Anticholinergic meds		(Berdot et al., 2009)a	
Laxatives		(Cumming et al., 1991)b	
Total number of drugs	(Campbell et al., 1989)a	(Cumming et al., 1991)b	(Lai et al., 2010)b
Poor adherence to meds	(Berry et al., 2010)a, (Campbell et al., 1989)a		
Inappropriate prescribing		(Berdot et al., 2009)a	

a=prospective study, b=retrospective / case control * More than 1 fall

The more medications taken regardless of type, increases the risk of falling (Campbell et al., 1989, Cumming et al., 1991). This may be a reflection of co-morbidities for which the drugs are required, impacting on falls risk in other ways. However, there are some medications

which have consistently demonstrated an association with increased falls and some medications where the effect on falls is not yet clear.

In terms of other general medication risk factors, those using medications deemed inappropriate using Beers list (Resnick and Pacala, 2012) have been found to have more falls (Berdot et al., 2009), as have those with low adherence to prescribed medications (Berry et al., 2010).

1.8.1.5.1 Psychotropic medication

Psychotropic medications are defined as centrally acting medications which include sedatives, hypnotics, antidepressants and antipsychotics. Systematic reviews have identified that psychotropic medications are associated with higher fall risk (Hartikainen et al., 2007). Leipzig, in a meta-analysis of drug related fall risk factors found that psychotropic medication use significantly increased the risk of falls and the effect was significant for hypnotic/anxiolytic, antidepressant and antipsychotic drug use. However, use of antipsychotics in psychiatric inpatients actually reduced falls (Leipzig et al., 1999a).

Hypnotic / anxiolytic medication

Benzodiazepines increase the risk of falls (Blake et al., 1988, Lord et al., 1995) and hip fracture. This risk appears to be highest when the medication is first started (Neutel et al., 1996). Takkouche (Takkouche et al., 2007), in a meta-analysis found that the risk of hip fracture was highest in the first 2/52 of starting the medication (RR=2.05 95%CI 1.28-3.28) and while continued use still resulted in a significantly increased risk, the risk reduced over time (RR=1.18 95%CI1.03-1.35). Herings (Herings et al., 1995) found that sudden dose increases or use of more than one benzodiazepine increased hip fracture risk.

Sedative drugs may increase falls risk by affecting postural stability and/or decision making. In a case control study involving healthy older and younger people, one group took Zolpidem or placebo and had 2 hours sleep and another group took a placebo and stayed awake for that time (Frey et al., 2011). After 2 hours they were asked to perform balance and cognitive tests. Those who used Zolpidem performed worse in all measures. The older people were more affected by the Zolpidem whereas the younger by sleep inertia. Van de Velde also found that timed up and go and walking speed improved after falls risk drugs were withdrawn (van der Velde et al., 2007).

Benzodiazepine use may also be a marker for other fall risk factors. Bartlett (Bartlett et al., 2009) found that being female, having arthritis, depression, alcohol dependency and using other medications particularly antidepressants were risk factors for benzodiazepine prescription.

Antidepressant medication

Antidepressant medication has consistently appeared to increase risk of falls and fractures (Blake et al., 1988, Kerse et al., 2008a, Lord et al., 1995). Leipzig's meta-analysis found that tricyclic antidepressants were associated with falls with an odds ratio of 1.51 (95%CI 1.14-2.00) (Leipzig et al., 1999a). Since that analysis, selective serotonin reuptake inhibitors (SSRI's) have been more commonly prescribed. However, SSRI's have also been implicated in risk of falling and fracture, even when results were adjusted for symptoms of depression (Kerse et al., 2008a).

1.8.1.5.2 Cardiovascular drugs

Drugs which have the potential to cause orthostatic hypotension may increase falls risk. Diuretics and anti-hypertensives are suggested candidates. In a systematic review,

Hartikainen found the relationship between falls and anti-hypertensives was present but weaker than that of psychotropic medication (Hartikainen et al., 2007). Leipzig, in a meta-analysis found that diuretics, particularly thiazide diuretics were associated with higher falls risk. Beta blockers, centrally acting anti-hypertensives, ACE inhibitors, calcium channel blockers and nitrates were not significantly associated with faller status. However, those taking type 1a anti-arrhythmics or digoxin were more likely to fall (Leipzig et al., 1999b). Again the relationship between starting new medication and falls risk was highlighted by Gribbin who found that the first 3 weeks using thiazides was the highest risk period (Gribbin et al., 2011).

1.8.1.5.3 Other drugs

There is less evidence for other drug groups in terms of increased risk of falls. In a review of non-steroidal anti-inflammatory use and falls, only 4 out of the 13 studies found an association with falls risk (Hegeman et al., 2009). Leipzig‘s meta-analysis found no significant increase in fallers in those taking any form of analgesia (OR=0.97 95%CI0.78-1.20) (Leipzig et al., 1999b). The measure of analgesia use and falls may in fact be a proxy measure of other potential risk factors such as arthritis causing muscle weakness and pain on movement. Scott found that statins were associated with muscle weakness and a trend towards increased falls risk scores (Scott et al., 2009).

1.8.1.6 Psychological issues

Fear of falling is associated with risk of further falls (Luukinen et al., 1996, Cumming et al., 2000, Friedman et al., 2002). The obvious mechanism for this is that perception of poor balance and realistic appraisal of falls risk leads to a fear in proportion to actual risk. There is good evidence that fear directly influences postural stability (Davis et al., 2009, Adkin et al.,

2002). Fear of falling is associated with activity restriction which in turn causes physical decline and higher falls risk (Deshpande et al., 2008) (Table 1.11).

Table 1.11 Studies where psychological issues were found to be significantly associated with falls outcomes in univariate or multivariate analysis

Psychological	Any fall	Multiple falls*	Fall injury / fracture
Cognitive impairment / dementia	(Woolley et al., 1997)b, (Prudham and Evans, 1981)b, (Tinetti et al., 1988a)a,		(Nevitt et al., 1991)a, (Tinetti et al., 1995a)a (Johansson and Skoog, 1996)b, (Baker et al., 2011)b
Fear of falling	(Cumming et al., 2000)a, (Murphy et al., 2003)a, (Friedman et al., 2002)a	(Luukinen et al., 1996)a	(Murphy et al., 2002)b
Dual tasking	(Shumway-Cook et al., 1997b)b, (Lundin-Olsson et al., 1997)a, (Verghese et al., 2002)a		

a=prospective study, b=retrospective / case control * More than 1 fall

The relationship between fear of falling and falls however, is not as simple as the obvious mechanism described above. Delbaere looked at falls risk using the physiological profile assessment (a combined measure of falls risk using contrast sensitivity, simple hand reaction time, knee extension strength, proprioception and postural sway) and fear of falling (Delbaere et al., 2010a). They identified four groups; vigorous (low actual falls risk and low fear of falls), anxious (low actual falls risk and high fear of falling), aware (high actual falls risk and high fear of falls) and stoic (high actual risk and low fear of falls). Both fear of falling and physiological profile assessment predicted future falls but being in the stoic group had a protective effect on falls risk. This suggests that anxiety about falling increases risk where physiological falls risk factors are not present.

1.8.2 Risk factors for falls in residential care

This section will be used to highlight the similarities and differences in falls risk factors between residential care and community dwellers.

There have been fewer studies investigating risk factors for falls in residential care dwellers. However, impairments in sensori-motor functions such as vision, sensation, reaction times and muscle strength as well as balance, gait and functional ability have similarly all been associated with falls in this population (Table 1.12, Table 1.13, Table 1.14).

Table 1.12 Studies where sensori-motor impairment was found to be significantly associated with falls outcomes in univariate or multivariate analysis

Sensori-motor function	Variables	Any fall	Multiple falls*
Vision	Contrast sensitivity	(Lord et al., 1991c)a	(Lord et al., 1991a)a,
	Visual acuity	(Jantti et al., 1993)a	
Sensation	Sensation (general)		(Robbins et al., 1989)b
	Proprioception		(Lipsitz et al., 1991)b, (Lord et al., 1991a)a
	Tactile sensitivity	(Lord and Clark, 1996)a	
Reaction times	Simple reaction times	(Lord and Clark, 1996)a, (Lord et al., 2003a)a†	
Muscle strength	Hip strength	(Robbins et al., 1989)b	
	Knee strength	(Whipple et al., 1987)b, (Wolfson et al., 1995)b, (Lord and Clark, 1996)a	(Luukinen et al., 1995c)a
	Ankle strength	(Whipple et al., 1987)b, (Wolfson et al., 1995)b	(Lord et al., 1991a)a

a=prospective study, b=retrospective / case control * More than 1 fall †Only in those able stand unaided

Table 1.13 Studies where balance/gait impairment was found to be significantly associated with falls outcomes in univariate or multivariate analysis

Balance and gait measures	Any fall	Multiple falls*
Sway		(Thapa et al., 1996b)a, (Lord et al., 1991a)a, (Lord and Clark, 1996)a
POMA		(Thapa et al., 1996b)a
Turning		(Lipsitz et al., 1991)b
Unsteady with external push	(Wolfson et al., 1995)b	
Walking speed	(Wolfson et al., 1995)b, (Lord and Clark, 1996)a, (Nakamura et al., 1996)a‡	
Reduced stride / step length	(Nakamura et al., 1996)a‡	(Luukinen et al., 1995c)a
Step variability	(Lord and Clark, 1996)a, (Nakamura et al., 1996)a‡	

a=prospective study, b=retrospective / case control * More than 1 fall ‡ sample of people with dementia

Table 1.14 Studies where functional impairment were found to be significantly associated with falls outcomes in univariate or multivariate analysis

Functional ability	Any fall	Multiple falls*
Activities of daily living	(Agashivala and Wu, 2009)b, (French et al., 2007)b, (Pellfolk et al., 2009)a‡	(Thapa et al., 1995)a
Walking ability – difficulty	(Eriksson et al., 2007)a‡, (French et al., 2007)b, (Kallin et al., 2005)b‡	
Walking ability – ability	(Myers et al., 1991)b	
Sit to stand ability – difficulty		(Lipsitz et al., 1991)b
Sit to stand ability – ability	(Pellfolk et al., 2009)a‡, (Kallin et al., 2005)b‡	
Walking aid	(Jantti et al., 1993)a, (French et al., 2007)b	

a=prospective study, b=retrospective / case control * More than 1 fall ‡ sample of people with dementia

Medical conditions which increase fall risk in community dwellers are also associated with falling in the those living in residential care with conditions such as depression and incontinence featuring as strong falls risk factors (Agashivala and Wu, 2009, Granek et al., 1987, Yip and Cumming, 1994, Robbins et al., 1989, Hasegawa et al., 2010) (Table 1.15).

Table 1.15 Studies where medical conditions were found to be significantly associated with falls outcomes in univariate or multivariate analysis

Medical conditions	Any fall	Multiple falls*
Depression	(Agashivala and Wu, 2009)b, (Granek et al., 1987)b, (Yip and Cumming, 1994)b	
Parkinson's disease	(Jantti et al., 1993)a	
Eye disease		(Luukinen et al., 1995c)a
Arthritis	(Granek et al., 1987)b	
Foot problems	(French et al., 2007)b	
Incontinence	(Robbins et al., 1989)b, (Yip and Cumming, 1994)b, (Hasegawa et al., 2010)a	(Hasegawa et al., 2010)a
Previous falls	(Stapleton et al., 2009)a, (Lord et al., 2003a)a, (Myers et al., 1991)b, (Kallin et al., 2005)b‡	

a=prospective study, b=retrospective / case control * More than 1 fall ‡ sample of people with dementia

Psychotropic medications including hypnotic/ anxiolytic (Fonad et al., 2008, Granek et al., 1987, Neutel et al., 2002, Kerman and Mulvihill, 1990) and antidepressant (Lipsitz et al., 1991, Granek et al., 1987) drugs as well as diuretics and anti-hypertensives (Myers et al.,

1991, Granek et al., 1987, Kerman and Mulvihill, 1990) have also been related to falls risk in the care home population. In this population more than those living in the community, multiple medication use may be a marker of comorbidity and risk factors related to these rather than the medications alone (Sterke et al., 2008). However, Wilson found no relationship between drug burden index and functional impairment in residential care dwellers (Wilson et al., 2010) (Table 1.16).

Table 1.16 Medications found to be significantly associated with falls outcomes in univariate or multivariate analysis

Medication	Any fall	Multiple falls*	Fall related injury / fracture
Psychotropic	(Agashivala and Wu, 2009)b, (Cooper et al., 2007)b, (Lord and Clark, 1996)a, (Lord et al., 2003a)a	(Thapa et al., 1995)a	
Benzodiazepines	(Fonad et al., 2008)b, (Granek et al., 1987)b, (Neutel et al., 2002)a, (Kerman and Mulvihill, 1990)b		(Mustard and Mayer, 1997)b (Fonad et al., 2008)b
Antidepressants	(Granek et al., 1987)b	(Lipsitz et al., 1991)b	
SSRIs			(Sterke et al., 2012a)a
Antipsychotics	(French et al., 2007)b, (Nygaard, 1998)a		(Mustard and Mayer, 1997)b
Antiparkinsonian	(Jantti et al., 1993)a		(Baranzini et al., 2009)b
Diuretics / antihypertensives	(Granek et al., 1987)b, (Myers et al., 1991)b, (Kerman and Mulvihill, 1990)b		(Myers et al., 1991)b
Antiarrhythmics			(Baranzini et al., 2009)b
Total number of drugs	(Neutel et al., 2002)a, (Kerman and Mulvihill, 1990)b, (Lim et al., 2001)b, (Robbins et al., 1989)b	(Lipsitz et al., 1991)b	(Baranzini et al., 2009)b
Inappropriate prescribing	(Agashivala and Wu, 2009)b		
Recent medication change	(Lim et al., 2001)b		
Risk factor medications $	(Stapleton et al., 2009)a		

a=prospective study, b=retrospective / case control * More than 1 fall

The main differences in risk factors between community and residential care were risk factors related to behaviour and those specific to the care setting.

1.8.2.1 Behavioural risk factors

Behaviours associated with increased falls risk in residential care have included wandering, agitation, verbally or physically abusive behaviour, disruptive behaviour and resistance to care (French et al., 2007, Hasegawa et al., 2010, Pellfolk et al., 2009, Stapleton et al., 2009, Thapa et al., 1995). Since different behaviours were measured in each study, it is not clear which behaviours are associated with the highest risk (Table 1.17).

Table 1.17 Studies where cognitive impairment or behavioural problems were found to be significantly associated with falls outcomes in univariate or multivariate analysis

Cognition and behaviour	Any fall	Multiple falls*	Fall related injury / fracture
Cognitive impairment/dementia	(French et al., 2007)b, (Stapleton et al., 2009)a, (Lord and Clark, 1996)a, (Gross et al., 1990)b, (Jantti et al., 1993)a, (Yip and Cumming, 1994)b, (Lim et al., 2001)b		(Myers et al., 1991)b
Behavioural problems	(Hasegawa et al., 2010)a, (Pellfolk et al., 2009)a, (Stapleton et al., 2009)a, (Kallin et al., 2005)b‡	(Thapa et al., 1995)a	(Hasegawa et al., 2010)a (Buchner and Larson, 1987)a‡

a=prospective study, b=retrospective / case control * More than 1 fall ‡Sample of people with dementia

1.8.2.2 Risk factors specific to the care home

1.8.2.2.1 Restraint use

Restraint can be done medically using sedation (already discussed as a fall risk factor) or by physical means such as bed rails, seat or wheelchair belts. Physical restraints are more likely to be used in people with dementia (Luo et al., 2011). In some cases use of such physical restraints increased the risk of falls (Fonad et al., 2008) but in one study bed rails protected

against falls in those with and without dementia but those with dementia who were restrained with trunk restraints fell more (Luo et al., 2011).

There is little evidence to suggest environmental risk factors are involved in fall risk in this population from the retrospective and prospective studies. However, focus groups with care staff suggested that falls could be caused by limited space, obstacles, equipment misuse, staffing shortages and poor organisation of care (Hill et al., 2009). Quality of the environment in long term care can affect behaviours (Bicket et al., 2010) which may in turn alter fall risk (Table 1.18).

Table 1.18 Studies where setting specific factors were found to be significantly associated with falls outcomes in univariate or multivariate analysis

Setting specific risk factors	Any fall	Multiple falls*	Fall related injury / fracture
Short length of stay	(Gross et al., 1990)b	(Luukinen et al., 1995c)a	
Use of restraints	(Fonad et al., 2008)b, (Luo et al., 2011)b‡		(Luo et al., 2011)b‡

a=prospective study, b=retrospective / case control * More than 1 fall ‡Sample of people with dementia

1.8.2.3 Non-linear patterns

In the residential care setting, several studies have found non-linear relationships between falls and functional ability. Thapa found differences in risk profiles for those who could walk compared to those who couldn't (Thapa et al., 1996a). The non-ambulatory group had a lower incidence of falls despite having more severe physical and cognitive disability. Falls in this group were more likely to involve equipment, occur during transfers and from chair height. Those who were able to sit out and transfer independently were the highest risk group. Lord and colleagues' results were similar, finding that those who could not get out of a chair without help and those with the worst balance function had the lowest risk of falls whereas those who were able to get out of a chair but had poor balance scores fell the most (Lord et

al., 2003a). On further analysis of this dataset, those who could stand unaided were also found to have a different falls risk profile to those who couldn't with risk factors being poor balance, previous falls, nursing home residence and urinary incontinence predicting falls in the former and previous falls, hostel residence and >9 medications in the latter (Delbaere et al., 2008).

1.8.2.4 Falls risk assessment tools for care home dwellers

In a survey of risk assessments used in care homes, Wagner found great inconsistency in tools used with many not being evidence based (Wagner et al., 2011). In a review of falls risk assessment tools for long term care, Scott and colleagues could suggest few tests as valid and reliable (Scott et al., 2007). The mobility interaction falls chart (Lundin-Olsson et al., 2000), the area of ellipse in postural sway (Thapa et al., 1996b) and the performance orientated mobility assessment (POMA) (Raiche et al., 2000) had strong predictive value but had not been externally validated. Sterke found that the POMA had acceptable specificity and sensitivity at predicting falls in people with dementia but that 41% of the participants could not understand part of the instructions (Sterke et al., 2010). A more recent review of risk assessment tools found that there was no difference between the St Thomas' risk assessment tool in falling elderly inpatients (STRATIFY), staff judgment and history of falls in overall falls prediction with staff judgement having the highest specificity but lowest sensitivity (Bentzen et al., 2011).

1.9 The problem of cognitive impairment

1.9.1 Definition of dementia and cognitive impairment (CI)

Dementia has been defined as "a cluster of symptoms and signs manifested by difficulties in memory, disturbances in language, psychological and psychiatric changes and impairments in activities of daily living (Burns and Iliffe, 2009). Cognitive impairment is a symptom of dementia and can be defined as scoring <24 in the mini mental state examination (MMSE) (Folstein et al., 1975).

There are many different causes of dementia. Nearly two thirds (62%) of the cases of dementia are due to Alzheimer's disease followed by vascular dementia (17%), mixed aetiology dementias (10%) and dementia with Lewy bodies (DLB) (4%) (Green, 2000).

1.9.1.1 Pathophysiology and clinical signs of dementia

The National Institute of Aging recently provided new criteria for the diagnosis of Alzheimer's disease (AD) (McKhann et al., 2011). Dementia is diagnosed when cognitive or psychiatric symptoms interfere with the ability to work or carry out usual activities of daily living, represent a decline from previous levels and are not as a result of delirium or other psychiatric disorder. There must also be evidence of cognitive/psychiatric symptoms in at least two of the following domains: memory, reasoning or judgement, visuospatial, language and personality. Probable AD is diagnosed when onset of symptoms is insidious and the course progressive and the most prominent symptoms in the domains of memory, language, visuospatial and executive functions. It should not be diagnosed where cognitive impairment has resulted from a known stroke, there is presence of multiple and extensive infarcts or symptoms are suggestive of Lewy body or fronto-temporal dementia or aphasia. Alzheimer's

disease (AD) is associated with neurofibrillary tangles and neuritic plaques and volume loss beginning in the medial temporal lobes progressing to full cortical involvement as the disease continues. Loss of subcortical neurones in the nucleus basalis and the locus coeruleus causes disruption to cholinergic and noradrenergic neurotransmitters. Medications which aim to address the disturbance in neurotransmitters associated with the disease can slow the rate of cognitive decline and include cholinesterase inhibitors (Donepezil, Rivastigmine and Galantamine) and NMDA type glutamatergic partial antagonists (Memantine).

Vascular dementia is diagnosed where cognitive impairment is caused by cerebrovascular disease. Reduction in blood supply to a specific area of the brain will result in ischaemic lesions and the location of such lesions determine the neuropsychological impairments (Green, 2000). Cerebrovascular disease may involve cortical infarctions where blockages of large vessels supplying cortical grey matter produce motor and cognitive symptoms with an acute onset. The other major form of cerebrovascular disease is small vessel disease. Ischaemia in the small vessels causes small lesions in white and grey matter and can often occur silently. The progression of symptoms may be gradual or abrupt depending on the size and number of lesions.

1.9.2 Prevalence of dementia

The dementia care UK report stated that in 2012, there were 800,000 people with dementia living in the UK at a yearly cost for health and social care of £23billion (Alzheimer's Society, 2012). This dwarfs costs of other high impact diseases such as heart disease, cancer and stroke. Around one third of the 800,000 are thought to be living in care homes and at least two thirds of care home residents have dementia. The Alzheimer’s Society (Alzheimer's

Society, 2012) suggests only 43% of those living with dementia are currently diagnosed as such.

In global terms, dementia affected 35.6 million people in 2010 at a cost of US$604 billion. With the ageing population, there are expected to be 115.4 million people with dementia worldwide by 2050. The costs of this cannot be accurately forecast as currently most care in low-middle income countries is currently undertaken by family members (WHO, 2012).

Dementia accounts for 11.9% of the years lived with disability due to a non-communicable disease and is the leading cause of disability in older people globally (WHO, 2008).

1.9.3 Falls and cognitive impairment

1.9.3.1 Prevalence of falls in people with CI

The prevalence of falls in people with cognitive impairment or dementia is at least twice that of older people who are cognitively intact. In one study looking at falls risk factors in a community dwelling population, 16 of the 24 (67%) with identified cognitive impairment fell in the one year follow up (Tinetti et al., 1988a). In another study, 80% of the 144 people with MMSE <24 who formed the control group for a randomised controlled trial fell over the one year follow up (Shaw et al., 2003). In two separate studies, 9.4% care home dwellers with dementia (Kallin et al., 2005) and 7.4% of community dwelling people with AD (Bassiony et al., 2004) were found to fall in the 1 and 2 weeks respectively preceding assessment. Comparing different types of dementia, Ballard found that while only 6% of participants with AD fell >5 times in 3 months, this occurred in 37% of those with Lewy body dementia.

In terms of falls rates, Van Dijk (van Dijk et al., 1993) reported a rate of 4.1 per person per year in nursing home residents with dementia. Similarly, Van Doorn reported that residents with dementia had 4.05 falls per person per year but also compared them to residents without dementia who had a rate of 2.33 (van Doorn et al., 2003). In another study where people with dementia were compared to healthy controls, those with dementia had 8 times the incident rate of falls (Allan et al., 2009).

1.9.3.2 Prevalence of fall related injuries in people with CI

The rate of injury from falls in people with dementia is also high. In a study following 827 community dwelling people with AD over a median of 3 years, 47% were hospitalised >2 times. Falls and syncope were the leading cause of hospital admission accounting for 26% of admissions in this group (Rudolph et al., 2010).

People with dementia have a threefold higher risk of hip fracture first identified by Buchner in 1987 (Buchner and Larson, 1987) and again by Baker in 2011 who found that people with AD had a hip fracture rate of 17.4 per 1000 person years compared to 6.6 for those without AD. The hazard ratio for hip fracture in AD was 3.2 (95%CI2.4-4.2) (Baker et al., 2011). Mortality following hip fracture is worse for those with AD. The hazard ratio for mortality within 6 months of hip fracture was 1.5 (95%CI1.1-1.9) with 27% of those with AD dying within 6 months of the fracture (Baker et al., 2011).

1.9.3.3 Why do those with CI have a higher risk of falls?

It is not clear why people with cognitive impairment have a higher risk of falls but the most probable explanation is that it is due to a combination of increased prevalence of known risk factors as well as specific factors relating to cognitive and non-cognitive (behavioural and

psychiatric) aspects of the dementia. The evidence available to support this hypothesis is discussed below.

1.9.3.3.1 Increased prevalence of known falls risk factors

Risk factors for falls identified in cognitively intact older people are more prevalent in those with cognitive impairment. This in many cases may be as a result of the neuropathological process which also causes the cognitive decline.

Balance and postural sway measures are worse in those with mild cognitive impairment (MCI) (Liu-Ambrose et al., 2008b, Boyle et al., 2007), AD (Suttanon et al., 2012) and executive dysfunction (van Iersel et al., 2008) and two studies have found that physiological profile assessment scores (a falls risk score calculated from vision, proprioception, reaction times, muscle strength and sway) are worse in people with MCI (Liu-Ambrose et al., 2008b) and AD (Lorbach et al., 2007). Slower gait velocity has been identified in those with AD (Suttanon et al., 2012, Alexander et al., 1995), MCI (Boyle et al., 2007), dementia (Tanaka et al., 1995) and poor working memory (Montero-Odasso et al., 2009) although one study suggested that after controlling for gait aid use and Parkinsonism people with dementia had faster gait (van Iersel et al., 2006). Increased gait variability is evident in those with cognitive impairment (Lamoth et al., 2011), AD (Wittwer et al., 2008) and poor executive function (van Iersel et al., 2008) and shorter stride length has been noted in people with dementia (Tanaka et al., 1995). Those with cognitive impairment are more likely to develop mobility problems over time (Buchman et al., 2011) and it also affects ability to dual task (Muir et al., 2012, Suttanon et al., 2012, Pettersson et al., 2005), coordination (Franssen et al., 1999) and obstacle contact when walking (Franssen et al., 1999). These findings suggest that the pathological changes that take place in the central nervous system associated with dementia

are likely even at very early stages of the disease to impact on sensorimotor performance. Most of the work suggests that gait slows with the onset of cognitive impairment. However, Van Iersel found that people with dementia actually walk faster when some important variables are considered. It is possible that people with dementia are less able to make accurate judgements of their gait and balance abilities before deciding on an appropriate gait speed. In other words, the conservative gait pattern described on page 35 is not initiated.

Other known fall risk factors more prevalent in those with cognitive impairment include orthostatic hypotension (Passant et al., 1997), low physical activity levels (Suttanon et al., 2012) and use of psychotropic medications (Giron et al., 2001, Lesén et al., 2011, Forsell and Winblad, 1997).

1.9.3.3.2 Risk factors related to cognition and behavioural and psychiatric symptoms

Cognition

When fallers and non-fallers are compared in cognitively intact populations, fallers have worse cognitive function. Anstey (Anstey et al., 2009) found that multiple fallers performed significantly worse in measures of executive function, processing speed, working memory and visual attention than single or non-fallers. Herman found that in a population of healthy older people, those in the worst quartile of executive function were 3 times more likely to fall in the 2 year follow up than those in the best quartile (Herman et al., 2010). In a retrospective study, Holtzer found reduced processing speed, executive function and attention were associated with increased risk of any fall and verbal IQ deficiencies associated with multiple falls, but memory was not significantly worse in fallers (Holtzer et al., 2007). Higher fall risk

scores measured using the physiological profile assessment have been associated with worse visual construction, executive function and memory (Martin et al., 2009).

Johnson in a longitudinal cohort study found that visuospatial dysfunction preceded the onset of working and verbal memory impairment and Alzheimer's disease by 2 and 3 years respectively (Johnson et al., 2009). It has been suggested that falls may be a prodrome to dementia and visuospatial dysfunction is a possible cause of this (Naslund, 2010).

The mini mental state examination (MMSE) is a useful tool to measure cognition as a fall risk factor. In a study prospectively following up the control arm of a randomised controlled trial, Gleason found that there was a significant increase in falls rates with every point decline on the MMSE between the maximum score of 30 and their lowest measure of 22. In another longitudinal cohort study of Hispanic Americans, errors in orientation and visual construction were the components of the MMSE most strongly associated with falls (Ramirez et al., 2010).

There is some evidence to suggest that fall related injuries are associated with impaired cognition. Older people with worse digit substitution tests and modified MMSE performances were more likely to have a fall related injury (Welmerink et al., 2010) and when Jabourain examined consecutive hospital admissions with fall related fracture, only 12% had MMSE >25 (Jabourian et al., 1994).

Theories as to how different domains of cognition may affect falls risk

Attention refers to the ability to be able to process information appropriately when the amount of information exceeds the available resources. Types of attention include the ability to select a task to attend to, to focus on a task and to divide attention between two or more tasks (Green, 2000). Impaired attention may cause less care to be taken over avoiding

obstacles, using a walking aid correctly or following instructions. Older people who have difficulties dual tasking are at higher risk of falling (Lundin-Olsson et al., 1997, Shumway-Cook et al., 1997b, Verghese et al., 2002) suggesting that difficulties in divided attention are associated with falls.

Executive function covers the ability to exert control over behavioural responses to situations, problem solving skills, development of strategies for completing tasks and awareness of abilities and appropriate behaviours (Green, 2000). Impaired executive function has been associated with falls (Herman et al., 2010, Holtzer et al., 2007) and possible reasons are proposed below. Failure to adequately plan through a task, carrying out the components in the incorrect order without an awareness of what is feasible depending on the situation and the person's functional ability may increase falls risk. Examples of this include undertaking actions which do not correspond to functional ability such as standing on a stool to change a light bulb when the person cannot stand without external support or failing to organise toiletries and clothes within easy reach before starting to groom and dress.

Language abilities include understanding and expressing language in spoken and written form, word finding and verbal fluency. Difficulties with language may result in poor understanding of instructions or safety advice. Difficulty expressing wishes and needs may also result in behaviours that present as impulsive. In those with poor balance, difficulty making a request may in some instances mean that they try to do a task themselves that a carer would normally do (for example reach for a walking aid placed too far away).

Visuospatial and visuoconstructive abilities contribute to the sensory input that controls mobility. Such skills are required to negotiate environments and avoid obstacles as well as maintain an upright posture and respond to external events in the surrounding environment.

Impairment in the cognitive processing of vision could result in postural instability or poor obstacle avoidance.

Memory encompasses declarative memory, such as memories of events, facts, people and places and non-declarative such as memories for movement and performing routine tasks. Disorders of memory can affect both declarative and non-declarative memory. Intact memory function requires memory acquisition, storage and retrieval and deficits can occur in any of these systems (Green, 2000). Memory could be implicated in falls risk as individuals may not be able to remember instructions to complete a task safely, may forget to use required walking aids or even lose procedural memories such as movements required to complete a task without losing balance.

Processing speed includes the ability to respond to situations in an appropriate time frame. This includes adequate stepping reactions to recover from a balance perturbation as well as information processing required to understand a problem and make a correct and timely response. Impaired reactions times are already known risk factors for falls as the motor output of these reactions are a necessity when maintaining postural stability (Lord et al., 1991b, Lord et al., 1994b). However, slow information processing may also result in inappropriate decisions while moving around.

In many cases it is difficult to see how dysfunction in a single cognitive domain could increase falls risk. However, in individuals with other risk factors such as poor postural stability, impaired cognition could significantly increase risk.

1.9.3.3.3 Behavioural and psychiatric falls risk factors

As well as the decline in various cognitive functions, the non-cognitive manifestations of dementia sometimes referred to as behavioural and psychiatric symptoms (BPS) may also impact on falls risk. BPS include apathy, sleep problems, irritability, psychosis, wandering, elation, agitation, depression and anxiety. The prevalence of BPS vary widely in the literature. In a recent review of systematic reviews, van De Linde found that BPS were present in 35-85%of people with MCI with most common symptoms being depression and anxiety. The prevalence in those with dementia living in care homes was 78% (van der Linde et al., 2012).

Behaviour

Studies examining behavioural risk factors for falls have largely been conducted in care home settings where the prevalence of dementia is high. Behavioural symptoms in general increase falls risk (Hasegawa et al., 2010, Thapa et al., 1995, Kallin et al., 2005) and one study found that BPS including difficult behaviours, depression, anxiety and impaired judgement or insight were better predictors of falls than medication use or cognitive status (Stapleton et al., 2009).

Specific behaviours associated with increased falls risk include escaping, restlessness, wandering, hyperactivity, verbally disruptive and attention seeking behaviours (Pellfolk et al., 2009, Kallin et al., 2005) and psychiatric symptoms associated with falls risk include depression, paranoia and hallucinations (Kallin et al., 2005). Of all of these symptoms Kallin found hyperactivity to be the independent predictor of falls (Kallin et al., 2005). Behavioural issues have also been associated with increased risk of fall related injuries (Hasegawa et al.,

2010) with Buchner finding that wandering behaviour was associated with increased hip fracture risk in older people with Alzheimer's disease (Buchner and Larson, 1987).

Impulsivity has been suggested as a cause of falls in hospital inpatients (Ferrari et al., 2010, Harrison et al., 2010) but has never been clearly defined. Impulsive behaviours on a background of poor postural stability may increase risk of falls.

Depression

The link between falls and depression has been discussed on page 39 and depression is highly prevalent in dementia affecting 15% of those attending dementia clinics (Reding et al., 1985), rising to 30% of those living in residential care (Wancata et al., 2003). Depression may even be the presenting symptom in some cases of dementia as Reding and colleagues found that over half of the older people diagnosed with depression with no cognitive symptoms went on to develop dementia within 3 years (Reding et al., 1985). In people with dementia, depression is associated with worse function, cognition and greater use of antipsychotic medication (Formiga et al., 2009).

Anxiety

Anxiety is more common in people with dementia. Between 8 and 71% of people with dementia will suffer some form of anxiety which is predictive of nursing home placement and functional impairment (Seignourel et al., 2008). There is some evidence that anxiety is a risk factor for falls in the general population (Vetter and Ford, 1989, Tinetti et al., 1995b).

1.9.3.4 Risk factor studies in cognitive impairment

Some studies have looked at falls risk factors specifically in people with dementia. Table 1.19 provides details of these. Although most of these studies have analysed falls risk in those living in residential care, there are limitations to each study.

1.9.3.4.1 Studies on mostly community dwelling participants

Allan looked at participants with different diagnoses of dementia as well as a group of healthy controls (Allan et al., 2009). Those with dementia had significantly more falls on the year follow up and significant and independent risk factors included depression, autonomic symptoms and orthostatic hypotension. Buchner investigated falls risk factors in people with Alzheimer's disease mostly living in the community. Risk factors identified on multivariate analysis for retrospective falls included muscle weakness, poor balance, arthritis and adverse drug reactions (Buchner and Larson, 1987). Kudo examined a group with diagnosis of AD or DLB. Multivariate analysis of independent and significant risk factors for falls in the preceding 4 months were DLB, visual hallucinations, Parkinsonism and cognitive fluctuation (Kudo et al., 2009). Lee found that the only independent risk factor for falls in the previous 12 months was urinary incontinence (Lee et al., 2011). While Maggio found carer burden and distress to be predictive of falls in the following 12 months (Maggio et al., 2010) and Ryan found that only physical function was different between those who fell in the previous 6 months and those who didn't in 43 people with AD (Ryan et al., 2011).

These studies have identified a range of possible risk factors including mood, medical, medication and cognitive risk factors. Of these studies only two risk factors have appeared in more than one study: muscle weakness and balance dysfunction.

1.9.3.4.2 Studies on mostly care home residents

Kallin questioned care staff to determine risk factors in residential care dwellers with dementia for falls over a 1 week period. Those who had previous falls, could rise from a chair, needed help to walk and had hyperactive behaviours were more likely to fall in this week (Kallin et al., 2005). Lowry looked at environmental risk factors in a population with

dementia where 66% lived in residential care. Environmental hazards were not associated with falls in the 3 month follow up and those who lived in residential care had significantly fewer environmental hazards than those living at home (1.8 vs 5.4) (Lowery et al., 2000). Pelfolk followed up 160 people with dementia living in group settings for 6 months and found that being dependent in hygiene, verbally disruptive, able to rise from a chair, participating in outdoor mobility and using a walking aid were independent predictors of falls (Pellfolk et al., 2009). Luo found that use of trunk restraints and not using bed rails increased falls risk in 5057 nursing home residents with dementia monitored over 180 days (Luo et al., 2011). In a study looking at falls risk factors in people with dementia on a psychogeriatric ward, Eriksson found that over a median of 53 days, independent risk factors for falls included being male, failing the copy design (overlapping pentagons) section of the MMSE, having difficulties with walking and functional impairment while statins were associated with decreased falls risk. Variables relating to cardiovascular function did not confound results and the authors suggested the statins may have had a cerebral protective effect (Eriksson et al., 2007).

A variety of risk factors were identified from these studies. However, being able to rise from a chair (Pellfolk et al., 2009, Kallin et al., 2005), needing help to walk (Kallin et al., 2005, Eriksson et al., 2007) , verbally disruptive and hyperactive behaviours (Kallin et al., 2005, Pellfolk et al., 2009) were the only risk factors identified in more than one study.

Table 1.19 Risk factors for falls in cognitive impairment

Study	Population	Measures taken	Falls outcomes	Significant on univariate analysis	Significant on multivariate analysis
(Allan et al., 2009)	179 participants (39 controls, 38 AD, 32 Vascular, 30 DLB, 40 Parkinson's disease dementia). 83% living in community	Medical history Previous falls Medication Dementia history CAMCOG Physical activity scale BMI POMA UPDRS (motor) ADLs Depression NPI Autonomic assessment	Single falls 65.7% of those with dementia fell on 12 month FU 9118 falls per 1000 person years.	Lower age DLB Falls and recurrent falls in previous 12/12 Using cardioactive medication Worse gait and balance Lower physical activity Depression Autonomic symptoms Autonomic neuropathy Orthostatic hypotension	Depression Autonomic score Orthostatic hypotension
(Buchner and Larson, 1987)	157 Alzheimer's type dementia 66% female Mean age 79 4% lived in care home Mean MMSE 17.6	Demographics Laboratory measures Comorbidities Lying/standing BP MMSE Dementia rating scale Adverse drug reactions Physical examination Tandem gait Rhomberg test	Single falls 42 had fallen since onset of dementing illness	Muscle weakness Poor balance Self reported musculoskeletal problem Poor tandem gait Arthritis Adverse drug reaction Reversible condition affecting cognition ≥5 drugs	Muscle weakness Poor balance Arthritis Adverse drug reaction
(Eriksson et al., 2007)	204 patients on psychogeriatric ward with diagnosis of dementia 126 Female Mean age 79	Demographics Function assessment staging scale (FAST) Medication use Walking ability MMSE BEHAVE-AD Lab measures	Single falls 40% fell 251 times over a median of 53 observation days FU Falls rate 6.2 per person per year	Male Walking difficulty Difficulty with copy design (from MMSE) Activity and diurnal disturbances in BEHAVE-AD Benzodiazepines	Male Failed copy design Walking difficulties Statins use FAST

Study	Population	Measures taken	Falls outcomes	Significant on univariate analysis	Significant on multivariate analysis
				Not taking statins, folic acid and beta blockers	
(Horikawa et al., 2005)	104 outpatient clinic patients with probable AD 75 Female Mean age 74-76	Demographics Medications Comorbidities MMSE MRI (deep and periventricular white matter lesions) Balance	Single falls 42% fell during 1 year FU	Neuroleptics Periventricular white matter lesions Balance	Neuroleptics Periventricular white matter lesions
(Jalbert et al., 2010)	Long stay nursing home residents with diagnosis of dementia	Demographics Medication use BMI Comorbidities ADLS Behavioural and psychiatric symptoms (BPS) Cognition Continence Walking aids Restraint use	*HIP FRACTURE* Case control study comparing 764 fracture cases with 3582 controls	Osteoporosis Diabetes Less likely to have visual impairment and schizophrenia or be overweight or obese Less functionally impaired BPS more common and severe Antipyschotic drug use	N/a
(Kallin et al., 2005)	2008 residential care dwellers with dementia Mean age 84	Multi dimensional dementia assessment scale (mobility, paresis, vision, hearing, function, BPS, cognition, continence and medications) Physical restraints	9.4% fell in one week assessment period	Inability to walk on stairs Able to rise from char Needs help to walk Needs walking aid Not bed bound Previous falls Intermediate ADL and cognitive function Behaviours: escaping, restless, wandering, verbally	Previous falls Can rise from a chair Walks with helper Hyperactive symptoms

Study	Population	Measures taken	Falls outcomes	Significant on univariate analysis	Significant on multivariate analysis
				disruptive/attention seeking, depression, hallucinations, paranoia and hyperactivity Number of drugs SSRIs Cyanocobalamin Olanzapine	
(Kudo et al., 2009)	78 community dwellers with probable AD (51) or DLB (27), able to walk without aid, no visual impairment and MMSE>10.	Demographics Unified Parkinson's disease rating scale MMSE Alzheimer's disease assessment scale NPI Medication use Cognitive fluctuation	Single falls 17 fallers in previous 4 months	DLB Visual hallucinations Parkinsonism Cognitive fluctuation	DLB Visual hallucinations Parkinsonism Cognitive fluctuation
(Lee et al., 2011)	159 community dwellers with dementia 61% female Mean age 77	Vision, hearing Mobility Balance Nutrition Continence Cognition Depression Polypharmacy ADLS IADLS	Single falls 54 fell in previous 12 months	Poor balance Poor nutrition Incontinence Depression Functional impairment Polypharmacy	Urinary incontinence
(Lowery et al., 2000)	62 Dementia patients referred to psychiatry services 36 Female Mean age 78 Mean MMSE 17	Environmental hazards checklist	Single falls 62 falls in 3 month FU (proportions not presented)	Environmental hazards not associated with falls Those living in own homes had more hazards (5.4 vs 1.8)	N/a

Study	Population	Measures taken	Falls outcomes	Significant on univariate analysis	Significant on multivariate analysis
	66% lived in residential care				
(Luo et al., 2011)	5057 nursing home residents with AD or dementia	Restraint: limb, trunk, chair, full or side bed rails Demographics Walking ability Length of stay ADLs Behavioural problems Continence Depression Medications Unit type	Single falls 36% fell over 180 day monitoring period (retrospective)	Use of trunk restraints Not using bed rails	Use of trunk restraints Not using bed rails
(Maggio et al., 2010)	110 people with dementia 67 Female Mean age 78 Mean MMSE 21	Comorbidity Function (ADLS and IADLS) CDR NPI Caregiver distress Caregiver burden	Single falls 12 month FU	Older age Lower education Worse ADL Worse IADL Worse CDR Antipsychotic drugs Extrapyramidal signs Visual impairment Caregiver not relative Formal care required More carer burden More carer distress	Carer burden Carer distress
(Pellfolk et al., 2009)	160 people with dementia living in group dwellings 126 Female Mean age 84	ADLS Behavioural and psychiatric symptoms Cognition Staff judgement Use of physical restraint	Single fall 40% fell in 6 month FU 2.6 falls per person per year	Independent eating Less physical restraint Able to rise from a chair Independently mobile Use of walking aid Mobile outdoors Wandering Escaping	Dependent in hygiene Verbally disruptive / attention seeking behaviour Able to rise from a chair Participates in outdoor walks Walks with aid

Study	Population	Measures taken	Falls outcomes	Significant on univariate analysis	Significant on multivariate analysis
				Passive Verbally disruptive Staff assessment Cognition and ADLs non linear pattern with more falls at intermediate levels	
(Ryan et al., 2011)	43 Community dwelling ambulatory, mild AD	Demographics MMSE Physical performance test 7	Single falls 30% fell previous 6/12	Worse PPT7	Item 7 of PPT7 (walking 25ft turning and returning 25 ft)
(van Dijk et al., 1993)	240 Psychogeriatric nursing home residents 194 Female Mean age 81	Dependency Aggressive behaviour Physical disability Depression Orientation and communication Apathy	Single falls 4.1 falls per person per year (2 year FU)	Male First week after admission Non-linear patterns with intermediate scores having highest risk for dependency, physical disability, orientation and communication and apathy.	N/a

Only two of the community and 4 of the care home studies used prospective follow up. Prospective follow up is seen as superior to retrospective as previous falls may be forgotten although this is less likely to occur in residential care settings.

Three of the studies described here provided data from medical, sensorimotor and balance, cognition and behavioural domains. Few studies examined sensorimotor function in depth, most used composite balance or gait scales or ratings of mobility. Only one study measured muscle strength, two measured balance and none measured sensation or reaction times. Specific domains of cognition associated with falls risk were detailed in only one study which identified visuospatial impairment as worse in fallers (Eriksson et al., 2007). However, this study only used MMSE to measure cognitive function, a measure which does not encompass all domains of cognition. Falls risk factors associated with DLB and Parkinson's disease may need to be considered separately as they have higher falls rates and disease specific risk factors such as visual hallucinations, autonomic failure and Parkinsonian balance and gait impairments (Allan et al., 2009).

1.10 Interventions to prevent falls – a summary of the evidence

The tenant of effective fall prevention is that interventions are targeted to identified risk factors. To improve understanding of the role of cognitive impairment on the efficacy of fall prevention interventions, the inclusion/exclusion of participants based on cognition and any measures of cognitive function has been described for each study.

1.10.1.1 Community dwellers

A wide variety of interventions have been tested in 112 randomised controlled trials detailed in Table 10.1 (appendix A). Interventions tested included comprehensive geriatric assessment, exercise, vitamin D, vision, cardiac, podiatry, medication review, risk assessment and occupational therapy. Interventions have had varied effects and the 2009 Cochrane review identified effective interventions as both home and group exercise, tai chi and multi-factorial assessments and interventions . Overall vitamin D supplementation did not reduce falls but the evidence was more convincing when it was used in people with low vitamin D levels. Home safety interventions were only effective in people with severe visual impairment or at high risk of falls. Single effective studies included withdrawal of psychotropic medications, a prescribing programme for physicians, insertion of pacemakers for cardio-inhibitory carotid sinus syndrome, anti-slip shoes in icy conditions and expedited removal of cataracts (Gillespie et al., 2009). A meta-analysis and regression of exercise to prevent falls found that exercise is an effective way to prevent falls and programmes including highly challenging balance training performed over more than 50 hours but not including walking programmes were the most effective (Sherrington et al., 2008, Sherrington et al., 2011).

Nearly three quarters (n=81, 72%) of the studies listed in Table 10.1 (appendix A) excluded participants on the basis of cognitive impairment. The most common reasons for exclusion on this basis were MMSE<24, a diagnosis of dementia or being deemed unable to understand enough to participate or consent. Only 30 (27%) of the interventions on community dwellers measured and presented details on cognitive

function. Where MMSE was measured (n=17) mean/median scores ranged between 23 and 29.5. Studies reporting the prevalence of cognitive impairment (N=8) where it was not an exclusion criterion found a median prevalence of 19% ranging between 5 and 34%.

1.10.1.2 Residential care dwellers

Fewer studies have been carried out in residential care settings, 29 of which are detailed in Table 10.2 (appendix A). Interventions tested in the care setting include multi-factorial assessment and intervention, exercise, vitamin D, tai chi, staff training, geriatric / medical assessment and intervention, medication review and sunlight exposure. Again not all interventions were effective and the Cochrane review found on meta-analysis that medication review and vitamin D reduced falls rates and multifactorial interventions provided by a multidisciplinary team or with comprehensive geriatric assessment reduced both falls rates and numbers of fallers (Cameron et al., 2010). Exercise did not significantly reduce falls or fallers. Of the 7 studies that tested exercise (Choi et al., 2005, Faber et al., 2006, Mulrow et al., 1994, Nowalk et al., 2001, Rosendahl et al., 2008, Schnelle et al., 2003, Sihvonen et al., 2004) only 1 study including 27 participants demonstrated a reduction in falls (Sihvonen et al., 2004).

Fewer studies excluded participants with cognitive impairment in this group with 8 (27%) of studies using some measure of cognitive ability as exclusion criteria. Of the 8 studies that presented MMSE scores, the median MMSE was 18. Where studies presented the prevalence of cognitive impairment (N=8), the median proportion with impairment was 56% ranging between 20-100% of participants.

1.10.1.3 Those with cognitive impairment

Despite the fact that cognitive impairment increases the risk of falls, there have been few studies targeting this group. Shaw carried out a randomised controlled trial to investigate the effect of a multidisciplinary falls prevention intervention on older people with MMSE<24 attending the emergency department following a fall (Shaw et al., 2003). The intervention consisting of a tailored physiotherapy programme, occupational therapy, medical assessment, medication review and cardiovascular investigations and intervention was delivered to 130 participants while 144 received usual care. Most (80%) of the participants lived in residential care and 90% were diagnosed with dementia. The mean MMSE for the intervention group was 14 compared to 12 in the control group signifying that the population were moderately cognitively impaired. The authors reported that 73% participants cooperated with the multifactorial assessment and while adherence to cardiovascular interventions was high (80-86%) exercise was moderate (61-64%) and environmental modification lower (39%). Risk factors for falls improved following the intervention with significantly better gait scores, fewer environmental hazards and correction of cardio-inhibitory carotid sinus syndrome. However, there was no significant reduction in the number of fallers, falls or fall related injuries. It is possible that falls were not reduced as people with dementia could not follow instructions to participate effectively. The data on adherence which is similar to other effective studies would suggest this was not the case. However, people with dementia may need a longer supervision period than the 3 months provided as to perform exercises effectively it is known that longer durations, ideally >6 months are required (Sherrington et al., 2008). The authors

suggested one explanation for the lack of effect was that different risk factors in this population may require different interventions.

Jensen tested a multi-factorial intervention using a cluster randomised controlled trial in residential care dwellers in Sweden (Jensen et al., 2002). The 11 week intervention based in 9 residences included staff education, environmental modification, exercise, supply or repair of aids, medication review, hip protectors, post fall case conferences and staff guidance. In the 34 week follow up period, there were significantly fewer fallers and falls in the intervention group. There was also a significant reduction in hip fractures. However, the research group went onto examine the effects of the intervention dependent on cognition (Jensen et al., 2003). In the group with MMSE≥19 there were fewer fallers and lower falls rates in the intervention group but there was no difference in either measure in the group with MMSE <19. That an intervention which worked in people with better cognition didn't work in people with moderate-severe cognitive impairment, reinforces the idea that people with cognitive impairment have different risk factors which require new and different interventions.

More recently, contrary to the above studies, two groups have found on post hoc analysis of falls prevention studies that those with lower cognition saw more benefits from an intervention. Rapp presented subgroup analysis of a 12 month multifactorial trial conducted in 6 nursing homes (Rapp et al., 2008). Interventions included staff training, exercise, environmental hazard checks and hip protectors. Cognitive impairment was defined using questions in the MDS RAI 2.0 and following the intervention those with cognitive impairment had a longer time to first fall and fewer falls than those who were cognitively intact. The authors suggested this may have

been due to the intervention being multidisciplinary addressing the multifactorial nature of fall risk in this group. Other possible reasons were that the exercise programme was supervised twice weekly for 12 months, a duration more likely to impact on falls risk, exercise was progressive and challenged balance, again more effective for falls prevention (Sherrington et al., 2008) and instructions and set up of the class were designed specifically with people with dementia in mind (personal communication).

The Kenosha County falls prevention intervention for community dwellers addressed risk factors relating to medication, gait and balance, cognition, mood, function and environmental hazards (Mahoney et al., 2007). Three hundred and forty nine participants took part in the randomised controlled trial and overall the programme was not effective at preventing falls. However, subgroup analysis identified that intervention participants with MMSE <28 had fewer falls over the 12 month follow up. The lowest MMSE in this study was 22 so this finding could not be generalised to those with moderate to severe cognitive impairment. Being a post hoc hypothesis involving small numbers for subgroup analysis indicates that interpretation of these results requires care.

A number of small studies have identified potentially useful interventions for older people with cognitive impairment. Shimada found that there were fewer falls during the time that enhanced supervision was used in long term residential care (Shimada et al., 2009). The enhanced supervision was provided two days a week for 25 weeks by a supernumerary healthcare assistant who had undergone additional training. Supervision involved checking rooms every hour, administering group conversations

or activities, ensuring ADLS were carried out safely, ascertaining toileting needs and providing supervision, offering other activities to wanderers, assisting with transfers, reminding to use the alarm for help and ensuring the environment was safe. Chenoweth and colleagues assessed the use of dementia care mapping and person centred care on care home dwellers with dementia and behavioural difficulties. Person centred care involves creating a personalised and holistic care plan while dementia care mapping analyses behaviour to better understand the causes and put into place a care plan to address root causes of behavioural difficulties. Measures of behaviour, medications and incidents (including falls) were taken at baseline, after the 4 month intervention and after a further 4 month follow up. Dementia care mapping resulted in significantly fewer falls between the baseline and follow up period (Chenoweth et al., 2009). Detweiler monitored falls for the year before and after a wander garden was installed in a secure residential unit for people with dementia. The residents had fewer falls and less serious falls in the year with the wander garden and the effect was particularly evident in high users (>22 visits) of the garden. The higher users of the garden also used fewer antipsychotic medications in the year following installation of the garden (Detweiler et al., 2009). Two of these studies were not randomised controlled trials and the other study did not use continuous prospective follow up, but these results suggest there is potential for interventions addressing dementia related behaviours to reduce falls.

There is some evidence that physical activity in earlier life reduces the risk of developing dementia (Andel et al., 2008) and that exercise can result in improvements in cognitive function in people with and without dementia (Hillman et al., 2008).

Specific medication can delay cognitive decline (Scarpini et al., 2003) and non-pharmacological interventions address behavioural and psychological symptoms effectively (Ayalon et al., 2006). Unfortunately, few of these studies have measured the effect on falls.

1.11 Conclusion

People with cognitive impairment are at high risk of falling and sustaining fall related injuries. To date the evidence to support effective interventions to prevent falls in this population is lacking. In older community dwellers without cognitive impairment, a great deal is known about the risk factors for falls and where interventions have been developed to target those risk factors many have been effective at preventing falls. In the care home population, many of the same risk factors have been identified with the addition of other risk factors particularly relating to behavioural and psychiatric symptoms of dementia. There is some evidence to suggest certain interventions are effective in residential care, but they may have differing effects depending on the level of cognitive impairment. Dementia is highly prevalent in the residential care setting and therefore interventions in this setting may be more effective if targeted to risk factors related to cognitive impairment. In order to target interventions, an understanding of the risk factors for falls in this population is required. The relative contribution of falls risk factors in residential care dwellers with cognitive impairment has not been thoroughly explored although there is evidence to suggest cognitive impairment increases the prevalence of risk factors known to cause falls in non-demented groups. There are also possible risk factors directly related to the dementia such as impaired cognitive processes and behavioural and psychiatric symptoms.

Therefore, in order to design effective targeted interventions in the future, better understanding of risk factors for falls in older people with cognitive impairment living in residential care is required by comprehensively measuring potential risk factors with prospective falls follow up.

This thesis investigated risk factors for falls in older people with cognitive impairment living in residential care and involved detailed measurement of known risk factors relating to medication, demographics and medical history, sensori-motor, gait and balance function as well as potential dementia specific risk factors including detailed neuropsychological testing and measurement of behavioural and psychiatric symptoms.

1.12 The research question

The overarching aim of this study was to comprehensively identify important risk factors for falls in older people with cognitive impairment living in residential care in order to develop a targeted intervention to be tested in future research.

The research question for this study was:

What are the risk factors for falls in older people with cognitive impairment living in residential care?

The hypothesis was:

Fall risk is increased by a combination of poor postural stability, impaired cognition and behavioural and psychiatric symptoms.

The objectives were:

1. To perform baseline measures in the domains of medical and demographics, sensorimotor, balance and gait function, behavioural and psychiatric symptoms neuropsychological function.

2. To develop and validate tests required to collect data where no suitable method was available (impulsivity, physical activity, judgement of balance function)

3. To collect follow up data for falls sustained in the 6 months following baseline assessment

4. To conduct univariate and multivariate analysis to determine differences between fallers and non-fallers in all domains

5. To use data to develop a falls risk screen to be used in future intervention studies

6. To develop a theoretical framework to explain falls risk in this population on which an intervention programme to target risk factors can be designed.

Defining Falls Risk Factors in Older Adults with Cognitive Impairment Living in Residential Care

Chapter 2

Methods

2 Methods

2.1 Study design

This was an observational cohort study involving baseline assessment with prospective 6-month follow-up to monitor for falls. Prospective follow-up was chosen in preference to collection of retrospective falls data for several reasons. Firstly, a full record of falls was not always available, particularly for those who had been living in the care home for less than one year. Secondly, even in individuals who do not have cognitive impairment, falls are poorly recalled (Cummings et al., 1988). This cohort of cognitively impaired participants would have been unlikely to accurately remember all previous falls. Thirdly, when retrospective outcome measurement is used in falls risk factor studies, the differences identified may be as a consequence of prior fall related injuries or fear of falling rather than the differences that pre-dispose an individual to falling.

The study was approved by the joint South London and Maudsley and Institute of psychiatry research ethics committee.

Unless stated otherwise, the researcher collecting data was Julie Whitney.

Data were collected for the following studies

1. A study to develop a screening tool to identify fall risk factors in residential care dwellers
2. A detailed study to identify fall risk factors in residential care dwellers with cognitive impairment. Within this study, 3 sub-studies were performed.
    a. The development of validation of a physical activity scale

b. The development of validation of an impulsivity scale

c. The development and validation of a measure of balance judgement

Data collected from detailed study participants were included in the screening cohort.

2.2 Participants

2.2.1 Selection of care homes

Care homes were selected to take part using the care quality commission website http://www.cqc.org.uk/ with the postcode for the research unit as the centre of the search and using the terms "care home" and care home with nursing" as service delivery and "dementia" and "older people" as specialist services. Starting with homes closest to the research unit, care home managers were contacted by telephone and given information about the study. Managers who were interested were sent a follow up e-mail with details of the project. Following this, a meeting was arranged. Care homes were contacted in order of proximity until the maximum number had been recruited.

2.2.2 Selection of participants

Once a manager had agreed to the care home participating in the study, residents were screened for inclusion / exclusion criteria. These were:

2.2.2.1 Inclusion criteria

- Aged over 60
- Permanent resident in the selected care home
- Stable for at least 6 weeks following hospital admission (to exclude delirium)

2.2.2.2 Exclusion criteria

- End stage illness likely to lead to death in 6 months
- Bedbound (never seated even with hoist)

Residents fulfilling these criteria were then approached about taking part in the study. In some care homes, an activity session or "tea party" was held to talk to residents about taking part. Residents who did not attend these activities were approached individually.

2.2.3 Ability to take part in the detailed risk factor study

The researcher determined whether the resident would be capable of undertaking the tests involved in the detailed risk factor study (chapter 4). Residents with severe cognitive or behavioural impairment, to the extent where they were not able to engage in a conversation at all due to agitation or confusion, were deemed to be incapable of participating in detailed baseline assessments. At least 2 visits to each resident at different times of day were carried out to confirm this. Providing an appropriate individual provided "assent" these residents were included in the screening tool study (chapter 3) where information was collected from notes and talking to carers.

2.2.4 Assessment of mental capacity

For the remaining residents, mental capacity to decide to take part in the study was assessed using the MacArthur competence assessment tool for clinical research (Appelbaum and Grisso, 2001) which involved providing each potential participant with information about the research, the risks and benefits. The resident was then asked questions to determine whether they could understand and remember what they

had been told about the procedures, appreciate what impact taking part would have on them, make reasoned decisions as to whether to take part and express their choice.

2.2.4.1 Residents with capacity

Residents with capacity were given an information sheet (see appendix B) and one week to decide whether to take part in the study. If they agreed to take part, a consent form (see appendix B) was signed.

2.2.4.2 Residents with incapacity

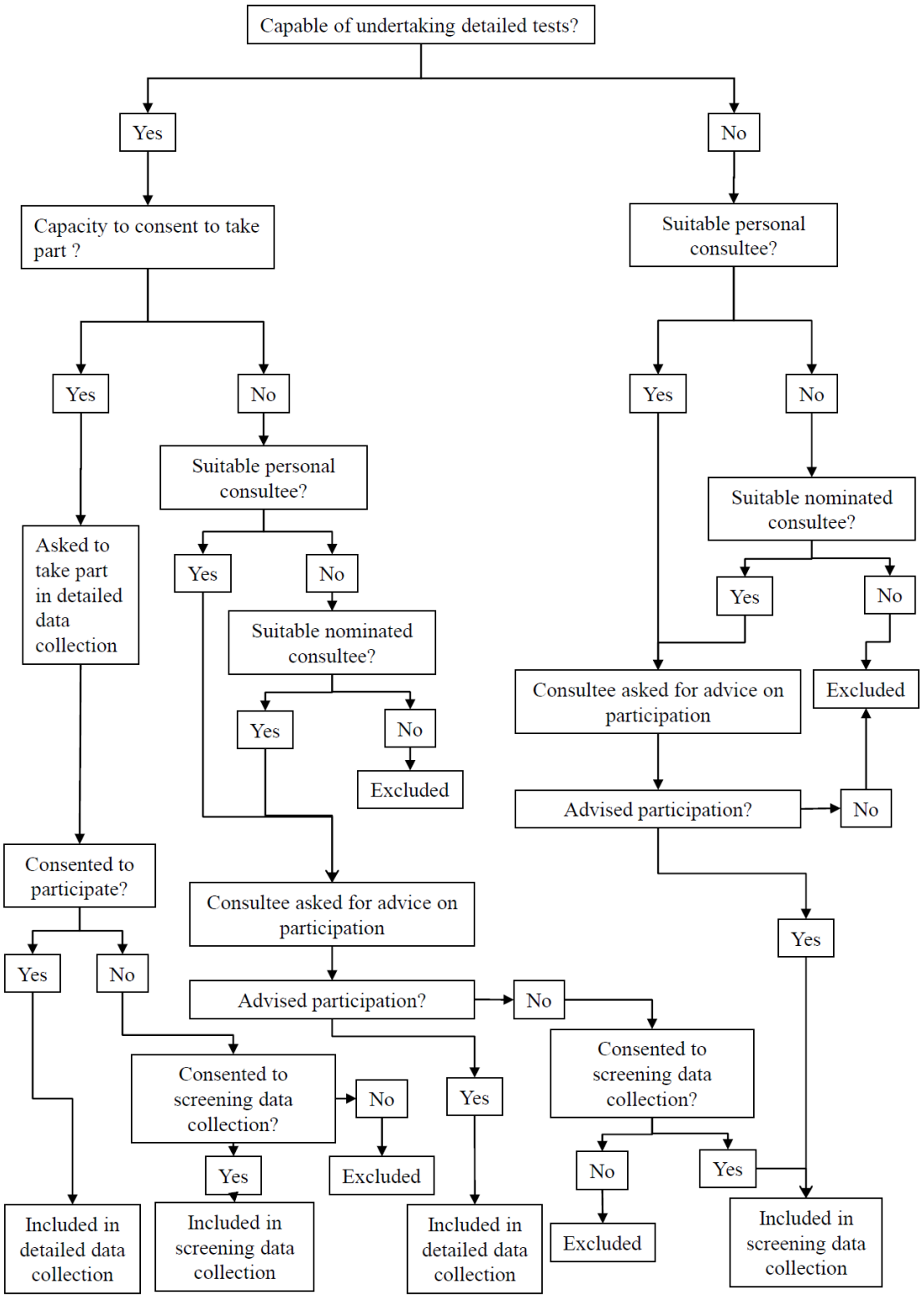
A personal consultee is described by the mental capacity act (HMSO, 2005) as "someone who knows the person who lacks capacity in a personal capacity who is able to advise the researcher about the person's wishes and feelings in relation to the project and whether they should join the research"

Personal consultees were sought for residents without capacity to consent. Care homes provided names and addresses of potential personal consultees who were sent a letter, information sheet, personal consultee form and other decision form as well as a stamped addressed envelope (see appendix B). If there was no response after 4 weeks or the "other decision form" suggested they did not wish to be a consultee, an appropriate nominated consultee was sought.

A nominated consultee is described by the Mental Capacity Act (HMSO, 2005) as "someone who is appointed by the researcher to advise the researcher about the person who lacks capacity's wishes and feelings in relation to the project and whether they should join the research".

Nominated consultees were also used for residents who had no appropriate relatives or friends to act as personal consultee. The nominated consultees were usually care managers or key workers for the residents involved. See appendix B for NC information and forms and Figure 2.1 for details of the recruitment process.

Figure 2.1 Flow chart illustrating recruitment process



2.3 Baseline measures

Baseline measures were commenced as soon as possible after recruitment. All data were collected within a 2 week period. Assessments were undertaken in four different domains including:

- Demographics, medical conditions and medication use
- Sensorimotor, gait and balance
- Behavioural and psychiatric symptoms
- Neuropsychological measures

Those with consent / assent to participate in the detailed study undertook detailed testing in all domains whereas participants of the screening study did not actively participate in tests, but the assessment process consisted of collecting data from talking to care staff and from medial and care notes. Data were either collected directly from the participant, from the medical and care records or by asking specific questions to care staff. Only care staff who knew the participant well (i.e. a key worker or unit leader) answered questions.

Table 2.1 illustrates the baseline measures undertaken in the screening study compared to the detailed study.

Table 2.1 Assessments undertaken in the two different studies

Screening study (Chapter 3)	**Detailed study (Chapter 4)**	
Medical conditions from the notes	Medical conditions from the notes	
	Lying/standing blood pressure	
	Neuro / orthopaedic assessment	
Record of current medications	Record of current medications	
Barthel	Barthel	
	Activity monitoring (accelerometer)	
	Physical activity questionnaire	
	Environmental checklist	
Sit to stand rating	Timed up and go	Knee extension strength
Standing balance rating	Six metre walk	5x sit to stand
	Postural sway	Propriocption
	5 step balance scale	Vision
	Grip strength	
Neuropsychiatric inventory	Goldberg anxiety scale	Neuropsychiatric inventory
Impulsivity questionnaire	Geriatric depression scale	Impulsivity questionnaire
Wandering index	Perceived reach test	Wandering index
MMSE (from notes)	ACE-R (MMSE)	Reaction times
	Boston naming test	Logical memory story
	Trail making test	

Table 2.2 provides information about the psychometric properties of the tests used in this study as well as any normative data and ability to predict falls.

Table 2.2 Psychometric properties of tests used

Test	*Validity / falls prediction*	*Cut points*	*Reliability*
Barthel (Mahoney and Barthel, 1965)	Good correlation with disability severity in people with neurological impairments (Hobart et al., 2001) Risk factor for falls on univariate analysis (Stalenhoef et al., 2002)	≤19/20 for falls (Stalenhoef et al., 2002)	Test retest in stroke patients: mean difference 0.4 (95%CI 0.01-0.90) (Green et al., 2001)
6 metre walk (SMWT) (Tiedemann et al., 2005, Tiedemann et al., 2008a)	Increased falls risk for SMWT taking ≥ 6 seconds = RR 1.8 Correlated with balance, strength, reaction times, vision, pain and emotional wellbeing	≥6 seconds for falls	Test – retest ICC 0.74 (0.52-0.87)
Timed up and go (TUAG) (Podsialdo and Richardson, 1991, Bischoff et al., 2003, Shumway-Cook et al., 2000, Steffen et al., 2002, Whitney et al., 2005)	Slower TUAG = increased falls risk scores Discriminates between fallers and non-fallers Correlated with balance, gait and functional ability	>10 seconds for fit community dwelling older people = increased falls risk >15 seconds for those already at high risk of falling = increased falls risk	Inter-rater Spearman's rank = 0.91(Bischoff et al., 2003) Test retest Spearman's rank = 0.96 (Bischoff et al., 2003) Inter-rater ICC = 0.99 (Podsialdo and Richardson, 1991) Intra-rater ICC = 0.99 (Podsialdo and Richardson, 1991) Inter-rater ICC=0.98 (Shumway-Cook et al., 2000)
Postural sway (Lord et al., 2003b)	Increased falls risk Related to muscle strength, reaction times and vision.	No clear cut point	Test retest Floor eyes open ICC 0.68 (0.45-0.82) Floor eyes closed ICC 0.85 (0.72-0.92) Foam eyes open ICC 0.57 (0.30-0.76)
Sustaining standing positions (Rossiter-Fornoff et al., 1995, Guralnik et al., 1994, Tiedemann et al., 2010)	Increased falls risk	<10 seconds for near tandem standing eyes closed for falls	Test retest for near tandem stand eyes closed ICC = 0.52 (0.21-0.74) Test retest correlation 0.66 (Rossiter-Fornoff et al., 1995)
Grip strength (Nevitt et al., 1989, Campbell	Correlated with pinch grip (Mathiowetz et al., 1984) Increased falls risk (Nevitt et al., 1989) but in meta-	<19Kg for falls (Nevitt et al., 1989)	Test retest right ICC = 0.91 (0.80-0.96), left ICC = 0.96 (0.89-0.98) (Bohannon and

et al., 1989)	analysis not significant OR 1.1 (0.8-1.5) (Moreland et al., 2004) Related to walking speed, chair raise ability and activities of daily living (Rantanen et al., 1999)	<120mmHg in women for falls (Campbell et al., 1989)	Schaubert, 2005) Test retest ICC ≥0.85 (Wang and Chen, 2010)
Knee extension strength(Menz et al., 2003, Lord et al., 2003b)	Impairment predicts falls	No clear cut point	Test retest ICC = 0.97 (0.93-0.98)
Sit to stand (Nevitt et al., 1989, Tiedemann et al., 2010)	Impairment predicts falls (Nevitt et al., 1989, Tiedemann et al., 2010) Significantly associated with other sensori-motor function (Sambrook et al., 2002, Lord et al., 2002) Predicts mortality and care home admission (Guralnik et al., 1994)	≤12 seconds for 5 STS for falls (Tiedemann et al., 2010)	Test retest ICC = 0.89 (0.79-0.95)
Proprioception (Lord et al., 2003b)	Impairment predicts falls	No clear cut points	Test retest ICC = 0.5 (0.15-0.74)
Contrast sensitivity (Melbourne Edge Test (Lord et al., 2003b))	Moderate to high correlations with other contrast sensitivity tests (Haymes and Chen, 2004) Impairment predicts falls (Lord et al., 2003b)	No clear cut points	Test retest ICC = 0.81 (0.7-0.88)
Goldberg anxiety Scale (Goldberg et al., 1988)	Sensitivity of 0.82 for anxiety disorder diagnosed using DSM-III	>5 for anxiety disorder	Not tested
Geriatric depression scale15 (Sheikh and Yesavage, 1986)	Mean sensitivity 0.90 and specificity 0.74 for diagnosis of depression in nursing home residents (from systematic review) (Wancata et al., 2006) Increased falls risk (Whooley et al., 1999)	>5 to diagnose depression >5 for falls	Test retest reliability correlation 0.85 (for GDS 30)
Neuropsychiatric inventory	Highly correlated with other measures of behaviour (behave-AD) (Cummings et al., 1994)	No specific cut point as summed score covers many disparate behaviours	Test retest reliability, Pearson correlation =0.79 for frequency and 0.86 for severity Inter- rater reliability, 95.7-100% agreement (Cummings et al., 1994)
Addenbrooke's cognitive examination	Good correlation with the clinical dementia rating for identifying dementia, Spearman Rho -0.32 ($p<0.001$)	<82/100 identifies dementia with sensitivity of 0.84 and	Not tested

ACE-R (Mioshi et al., 2006)	Able to identify different types of dementia using ratios of language to orientation and memory scores.	specificity of 1.0	
Mini Mental State Examination	Able to identify those with dementia and correlated with Wechsler Adult Intelligence Scale (Folstein et al., 1975) Predicts recurrent falls (Graafmans et al., 1996)	Score <24/30 defined as cognitive impairment <24/30 for recurrent falls	Test retest Pearson correlation = 0.89 Inter rater Pearson correlation =0.83 28 day test retest on stable patients Person correlation = 0.99 (Folstein et al., 1975)
WMS-III Logical memory story 1	Score ≤7 sensitivity 78.8 and specificity 88.5 for identifying dementia (Palmer et al., 2003)	≤7 for dementia	Test retest (11 months) Pearson correlation = 0.70 (Dikmen et al., 1999)
Simple hand reaction times (Lord et al., 2003b)	Increased falls risk Related to postural sway	No clear cut point	Test retest reliability ICC=0.69
Trail making test A	Sensitive to impaired frontal lobe function (Demakis, 2004).	Normative data for ages 81-83, 50 percentile scores = 43-52 seconds to complete (Ivnik et al., 1996)	Test retest (11 months) Pearson correlation = 0.79 (Dikmen et al., 1999)
Boston naming test (shortened version)	Correlated with mini mental state examination and longer form of BNT in older people with dementia (Calero et al., 2002) and AD (Mack et al., 1992)	Normative data for midpoint aged 83=12.7 (Kent and Luszcz, 2002).	Test retest (11 months) Pearson correlation = 0.92 (Dikmen et al., 1999)
Stops walking when talking test	Related to gait stability, dependence in activities of daily living and mobility speed. Those who stopped were more likely to fall (Lundin-Olsson et al., 1997)	Stops walking when talking	Not tested

2.3.1 Demographic, medical, medication and environmental measures

2.3.1.1 Demographic data collection

Data on age, sex and ethnicity were collected by asking participants and/or recording information from care records.

2.3.1.2 Medical conditions and examination

2.3.1.2.1 Medical history

All current and previous medical conditions found in care and medical records were noted. All records were examined in detail to determine diagnoses of conditions related to falls which included; arthritis, diabetes, hypertension, osteoporosis, urinary incontinence, Parkinson's disease and stroke. Any dementia diagnosis or other indication of cognitive impairment was also noted.

Care records and care home accident reporting systems were used to determine falls in the past year. To avoid inaccuracy in reporting, where a participant had lived in the home for less than 1 year, a reported fall (prior to admission) would only be recorded if it was the reason for the admission or there was a documented injury (such as fracture).

2.3.1.2.2 Lying / standing blood pressure measurement procedure

Blood pressure (BP) was measured using the European Cardiology Guidelines (Moya et al., 2009). The participant was asked to lie supine for 5 minutes prior to the first measurement. BP was then measured using an electronic sphygmomanometer (Omron automatic blood pressure monitor Model HEM-757) on the right arm (supported at heart height) along with a record of pulse. The participant was then asked to stand up

and blood pressure and pulse measurements taken 1 and 3 minutes after standing. Participants who were unable to stand had one blood pressure measurement taken in sitting.

Orthostatic hypotension (OH) was defined using European syncope guidelines. Classical OH is defined as a drop of ≥20mmHg systolic and ≥10mmHg diastolic after 1 minute. Initial OH, defined as a drop in beat to beat BP within 30 seconds of standing was not be collected as our method would only pick up BP 1 minute after standing up. Delayed OH is a slow decline in systolic BP from 3 minutes after standing. Postural orthostatic tachycardia syndrome (POTS) is defined as increase in heart rate of >30bpm or to >120bpm with BP instability on standing up (Moya et al., 2009).

2.3.1.2.3 Neurological/musculoskeletal examination procedure

A basic neurological examination was performed which included testing of muscle power and tone and reflexes, sensation to soft touch and a cranial nerve examination. Any abnormalities were noted.

2.3.1.3 Medication history

All medications used by each participant and their dose and frequency were recorded directly from drugs charts and coded using the British National Formulary.

2.3.1.4 Barthel scale

Current care records and discussion with carers were used to compile the Barthel index. The Barthel index score measured functional ability in domains of feeding, bathing, grooming, washing, dressing, continence, toileting, transfers, mobility and

ability to use stairs (Mahoney and Barthel, 1965). A higher score indicates a more independent participant. A copy of the index is included in appendix C.

2.3.1.5 Environmental checklist

An environmental assessment was conducted for each resident following the assessment tool recommended by Queensland health falls prevention guidelines (Queensland Government, 2003). This involved identifying environmental risks in the bedroom, surrounding furniture and walking aids. A copy of this assessment is included in appendix C. Footwear type was also recorded.

2.3.1.6 Physical activity

2.3.1.6.1 Physical activity questionnaire procedure

Physical activity in care home residents could not be measured using questionnaires designed to determine physical activity in community dwellers due to their lack of involvement in instrumental activities of daily living and exercise (which make up the majority of questions in such scales) (Jorstad-Stein et al., 2005). Carers were asked to rate mobility and balance abilities, levels of daily mobility, wandering and outdoor mobility using a newly designed physical activity scale. More information about the development and validation and a copy of this questionnaire can be found in chapter 5.

2.3.1.6.2 Accelerometer procedure

Physical activity was measured for at least 24 hours using the ActivePal body fixed sensor (Figure 2.2). It was applied to the anterior part of the mid-thigh and secured in place with either activePal “Stickies” (an adhesive gel pad) or a layer of Tegaderm

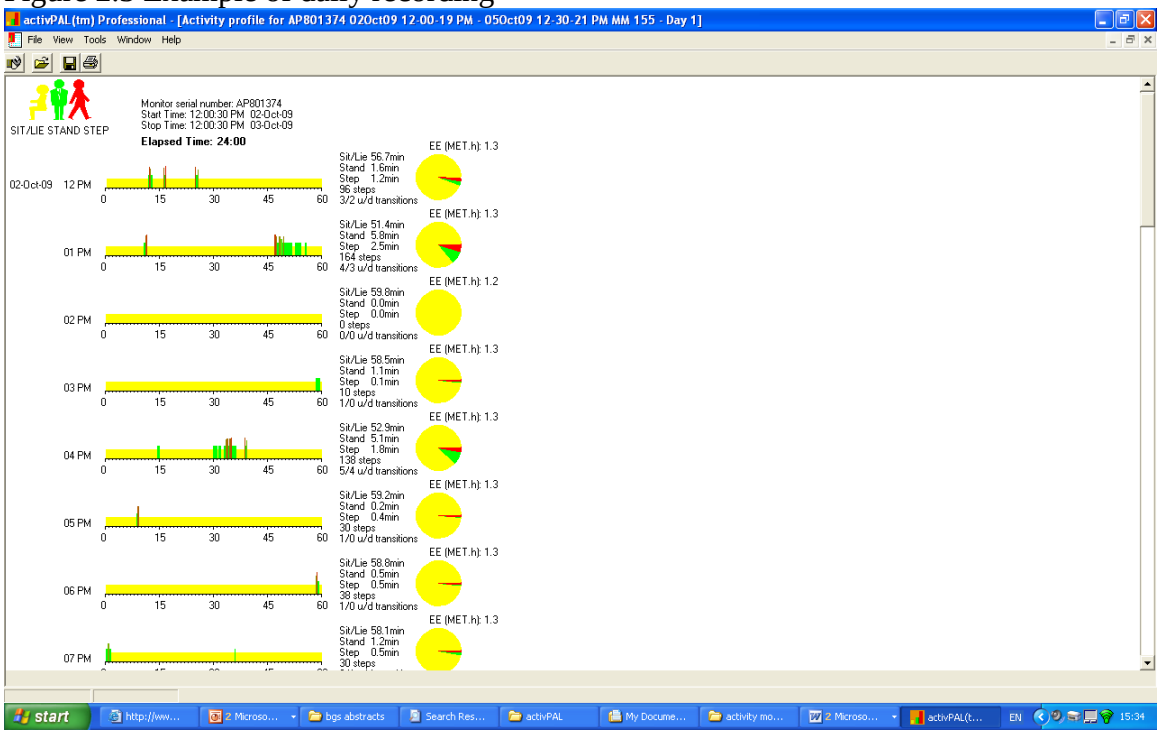
dressing. The sensor was removed after 3 days and data downloaded using the associated software. Information was recorded on daily activity including:

Figure 2.1 Example of ActivePal sensor

- Number of times standing up from sitting / sitting down from standing
- Number of steps taken
- Time spent lying or sitting
- Time spent standing
- Time spent walking

An average daily score for each of these measures was calculated using each full day's recording collected (Figure 2.3).

Figure 2.3 Example of daily recording



2.3.2 Sensorimotor, gait and balance measures

The reasons for choosing measures in each of these domains will be supported with research evidence.

2.3.2.1 Measurement of gait parameters

Slow walking speed has been associated with an increased risk of falls in older people (Tinetti et al., 1988a, Bath and Morgan, 1999) and walking tests have been included in commonly used falls risk assessments (Podsialdo and Richardson, 1991).

2.3.2.1.1 Six metre walk procedure

The participant was asked to walk 6 metres at their usual speed wearing their usual footwear and using their usual walking aid. A 6 metre distance was marked out with

lines on the floor. Participants started the walk at least 1 metre before the start line and were asked to stop at least 1 metre after the finish line in order to exclude measurement of accelerations and decelerations. Time taken to walk 6 metres was measured in seconds using a stopwatch and the number of steps taken were counted.

2.3.2.1.2 Timed up and Go procedure

A 3 metre distance was measured from a standard armchair (43cm) and marked on the floor with tape. Participants undertook this test walking at their usual speed, wearing their usual footwear and using their usual walking aid. They were instructed to stand, walk to the tape, turn around and return to the chair to sit down. The time taken from when the participant left contact with the chair to when they resumed contact was measured in seconds using a stopwatch. One test was used.

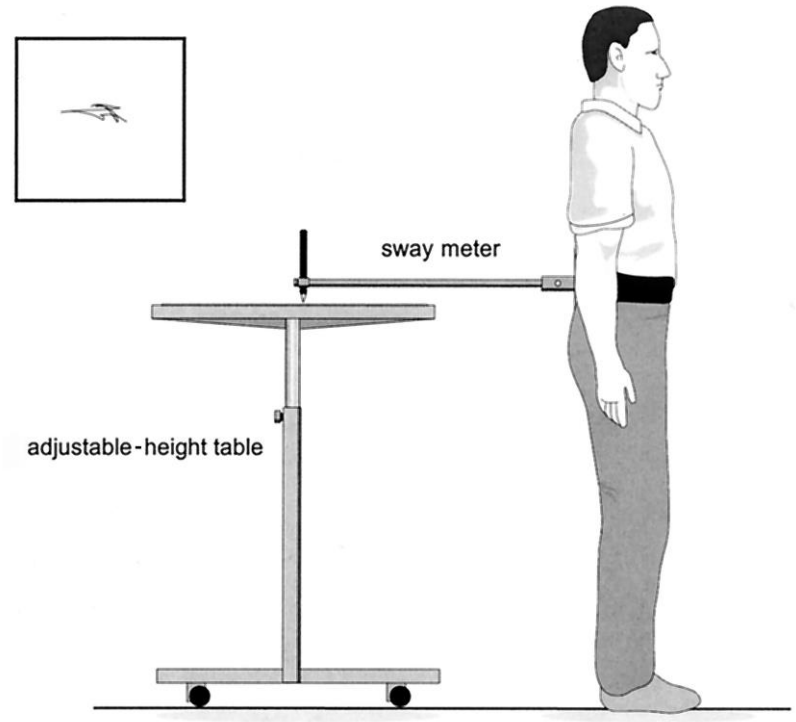
2.3.2.2 Measurement of postural stability

Postural stability has been defined as "the act of maintaining, achieving or restoring a state of balance during any posture or activity" (Pollock et al., 2000). Postural stability has three components; maintaining a specific posture, moving between positions and restoring stability when an internal or external force has displaced balance. Good postural stability requires integration of sensory input from vision, the vestibular system and somatosensation and response with muscle activity of appropriate timing and force. Postural stability declines with age (Lord and Ward, 1994, Sheldon, 1963) and there is a strong link between poor performance in measures of postural stability and fall risk (Fernie et al., 1982, Cho and Kamen, 1998). It is particularly evident for measures of standing balance and for tests which involve internal perturbations as part of functional activity (Sturnieks et al., 2004).

2.3.2.2.1 Postural sway procedure

A portable sway meter that measured anterior-posterior and medio-lateral sway at waist level was used (Lord et al., 2003b). The sway meter was a 40cm rod attached to the waist extending behind the participant. A vertically mounted pen at the end of the rod was used to measure sway on graph paper held on an adjustable table (Figure 2.4). Participants performed the test in bare feet standing in front of a firm support. They were instructed to look ahead and stand as still as possible after letting go of the support surface. Sway was measured for 30 seconds using a stopwatch. If the participant could not sustain the position for 30 seconds, 3 attempts were made before the test was abandoned. Sway measurement was recorded in 3 different conditions:

Figure 2.4 Postural sway measurement



- Standing on the floor eyes open
- Standing on the floor eyes closed
- Standing on a (40x40cm) 15mm thick medium density foam rubber mat with eyes open

If 30 seconds in a condition could not be completed, testing did not progress to the next condition.

The maximum excursion of anterio-posterior was multiplied by the maximum medio-lateral excursion recorded on the graph paper (mm^2).

2.3.2.2.2 Sustaining standing positions procedure

Participants started the test with bare feet shoulder width apart in front of a firm support, looking ahead. Participants held onto the support to achieve the position required and were then asked to let go and stand as still as possible.

The time the position was sustained was measured with a stopwatch until either 10 seconds had elapsed or the participant held onto support, moved their feet or needed physical assistance to maintain balance. Progress to the next more difficult position was only made if the participant successfully maintained the previous position for 10 seconds. If they did not, the time the position was sustained at that level was recorded and the test terminated. Foot positions were progressed in the following order:

1. Standing feet shoulder width apart
2. Standing feet side by side (within 2.5cm)
3. Near tandem standing (the side of the heel of one foot touching the big toe of the other foot)

4. Near tandem standing eyes closed
5. Tandem standing

The integer for the total balance score was the number in the order of the positions sustained which the participant managed for 10 seconds (see scale above). The decimal number given after this represented the number of seconds spent in the next most difficult position. For example, a score of 2.5 would mean the participant had been able to stand 10 seconds with feet side by side and only 5 seconds in near tandem standing.

2.3.2.2.3 Questioning care staff

Care staff were asked to rate standing balance ability on the following scale:

1 – Unable to stand
2 – Requires assistance of 2 to remain standing
3 – Requires assistance of 1 to remain standing
4 – Requires use of walking aid to remain standing
5 – Stands without aid / assistance but unsteady
6 – Stands without aid / assistance steady

2.3.2.3 Measurement of strength

Muscle weakness particularly in the lower limbs is associated with increased risk of falls (Lord et al., 1994b, Campbell et al., 1989, Moreland et al., 2004). Lower limb weakness leads to difficulty with functional activities such as rising from a chair, managing steps and stairs and impairs postural stability (Nevitt et al., 1989, Pearson et al., 1985). Older people lose muscle strength by on average 1-2% and muscle power by 3.5% a year after the age of 65 (Skelton et al., 1994).

2.3.2.3.1 Grip strength procedure

Participants sat in a standard 43cm height armchair. The dominant hand was tested. The participant was positioned with their shoulder adducted and in neutral rotation, the elbow flexed at 90° and the wrist in a comfortable position to maximise grip strength. A Northcoast™ hand dynamometer was used to measure grip strength and all participants tested on setting 2 to minimise time taken to gather data. Participants were instructed to squeeze the dynamometer as tightly as possible and the peak torque was measured in Kg. The best of the three measurements was recorded. Participants were given verbal encouragement while undertaking the test and were informed of their results after each repetition to encourage maximal effort.

2.3.2.3.2 Knee extension strength procedure

Participants completed this test if they were able to get onto the high testing chair. The dominant limb was tested, participants were asked which leg they would use to kick a football and this was deemed to be the dominant limb. Participants sat on the testing chair with the dominant leg strapped into the strain gauge, the hips and knees flexed at 90°. They were asked to hold onto the chair for support and try to straighten the leg in question as much as possible against the gauge. The best of the 3 measurements was recorded. Participants were given verbal encouragement and told their results after each repetition to maximise effort (Figure 2.5).

Figure 2.5 Knee extension strength

2.3.2.3.3 Sit-to-stand test procedure

Participants were seated in a standard chair (43cm) and firstly asked if they could stand up with their arms folded across their chest. If a participant attempted to push up using the back of their legs or leaning on their arms, this was discounted. If the participant was not able to stand without arms, they were asked to try using the chair arms to push up. Sit to stand ability was ranked in the following way:

1. Unable
2. Required assistance from another person
3. Pushed themselves up using their hands
4. Capable (not using arms)

Those who were capable of standing without using their arms went on to perform the 5 times sit to stand test. Participants were asked to cross their arms and stand up until fully straight and then sit down again and repeat 5 times. The time taken was measured using a stopwatch.

Care staff were also asked to rank sit to stand ability using the same 1-4 scale as above.

2.3.2.4 Measurement of sensory function

Sensory function including vision, peripheral sensation and vestibular function are important for the control of postural stability. Vision declines with age (Gittings and Fozard, 1986) and deficits in vision are associated with increased fall risk (Ivers et al., 1998). Proprioceptive decline as a component of peripheral sensation is also associated with increased risk of falls (Lord et al., 1994b). Although vestibular function may be associated with fall risk, it was not measured in this study due to lack of easily conducted valid and reliable tests.

2.3.2.4.1 Proprioception procedure

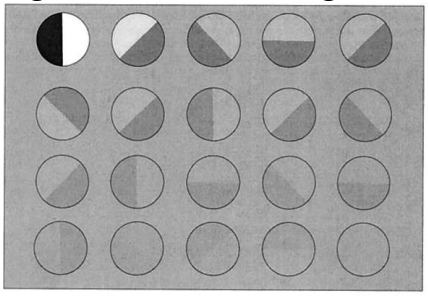
The test was only completed if the participant could get into the high test chair. Once sitting in the test chair, a vertical clear acrylic sheet (60cm x 60cm x 1cm) inscribed with a protractor was placed between the legs. The medial aspect of the interphalangeal or the metatarsophalangeal joint (whichever was more medial) was marked with a pen as the participant was barefoot. They were instructed to close their eyes and match the big toes on either side of the acrylic sheet. The difference between the toes was measured in degrees. After 2 practice trials, five measures were recorded (Figure 2.6).

Figure 2.6 Proprioception test

2.3.2.4.2 Vision procedure

The Melbourne Edge Test consists of 20 circles split into two contrasting halves with reducing contrast progressing from the start of the test. The halves were orientated in four different variations and a key card was provided so that participants could choose the correct variation of orientation. Participants were seated and the card placed in front at a 45° angle. Lighting was difficult to control in the care homes but electric lights were turned on for this test. The test score was the lowest contrast successfully identified (Figure 2.7).

Figure 2.7 Melbourne edge test



2.3.2.5 Physiological profile assessment falls risk score

The physiological profile assessment falls risk score (PPA) was calculated using the online calculator http://www.neura.edu.au/fbrg using a combination of Melbourne edge test, proprioception, hand reaction time, knee extension strength and postural sway standing on foam.

2.3.3 Measures of behavioural and psychiatric symptoms

2.3.3.1 Impulsivity

Impulsive behaviours may increase falls risk as the individual attempts to carry out activities without judging the safety and feasibility of such actions first. It is thought to contribute to falls in hospital inpatients (Ferrari et al., 2010, Harrison et al., 2010). However, there is no feasible method for measurement or standard definition of impulsivity in this context. Therefore a set of questions to address this issue were designed. Impulsivity was defined as "behaviour without adequate thought" (Moeller et al., 2001) and the following questions answered by care staff:

Impulsivity questionnaire	Answer (point scored)
Does …….. tend to be impulsive when moving around? *[Impulsive means – rushes to carry out an activity without thinking about it first]*	Yes (1) No (0)
These are examples of impulsive behaviours could you tell me if …….. has demonstrated any of these behaviours?	(each question)
1.Trying to sit down before getting right up to the seat / toilet / bed	Very Frequently (4) Frequently (3)
2.Attempting to stand before wheelchair footplates have been moved/ brakes applied /frame placed in front	Often (2) Occasionally (1)
3.Trying to walk without help when they have been asked not to?	Never (0) N/a (0)

Details of the development of this scale can be found in chapter 6.

2.3.3.2 Anxiety

An association between anxiety and falls has been demonstrated (Tinetti et al., 1995b) and anxiety is common in older people with dementia (Seignourel et al., 2008). Anxiety was measured using the Goldberg Anxiety Scale (Goldberg et al., 1988).

2.3.3.2.1 Goldberg anxiety scale procedure

The Goldberg Anxiety scale consists of four initial yes/no questions to determine the state of anxiety. If more than two questions had a positive reply, a further 5 questions were asked. A copy of the questionnaire can be found in appendix C.

2.3.3.3 Depression

Depression has been linked to falls (Nevitt et al., 1989) and may influence other risk factors for falls such as using antidepressant medication or lower levels of physical activity. Depression was measured using the Geriatric Depression Scale 15-item questionnaire (Yesavage, 1988).

2.3.3.3.1 Geriatric Depression Scale procedure

The Geriatric Depression Scale is a 15 item scale with yes/no answers to determine depressive symptoms. Each participant was asked the 15 questions and 1 point was scored for each answer suggestive of depression. See appendix C for a copy of the scale.

2.3.3.3.2 Judgement of balance abilities

Judgement was measured using the perceived reach test. There was no available and feasible measure to test judgement of balance ability in this population. Therefore a

test was devised for the purpose of this study. In depth analysis of this test is covered in chapter 7.

2.3.3.3.3 Perceived reach procedure.

Participants performed this test if they were able to stand independently. The first component of the test was to stand on a 25cm step. This was only conducted if they were able to safely get onto the step.

Once standing on the step with their toes level with the edge of the step, participants were asked to look at a vertical rod 1 metre anteriorly. They were then asked, as the vertical pole was moved slowly towards them "without trying to reach the pole, tell me when you THINK you could reach it". When the participant indicated they could reach the pole, the distance in mm from the step was noted using a ruler which was incorporated into the sliding mechanism. The participant was then asked to step off the step, the step was moved and the participant asked to stand with their toes against a marker placed on the floor. Again the participant was asked to look at the vertical pole, placed 1 metre anteriorly and again indicate when they thought they would be able to reach it. Finally, the participant was asked to reach as far forward as possible with their dominant arm and the distance was measured. The test was repeated 3 times.

2.3.3.4 Agitation and other dementia related behaviours

Dementia related behaviours were measured using the neuropsychiatric inventory and wandering scale. These questions were answered by a carer who knew the resident well.

2.3.3.4.1 Neuropsychiatric inventory procedure

The neuropsychiatric inventory consists of 12 questions about the presence of behaviours associated with dementia (Cummings et al., 1994). Questions cover delusions, hallucinations, agitation, depression, euphoria, apathy, disinhibition, irritability, motor disturbance, night time behaviours and appetite. Where any symptom was present, points were added for the frequency and severity of the symptoms. See appendix C for further information.

2.3.3.4.2 Wandering scale procedure

Wandering was defined using the scale from the minimum data set (MDS) cognition scale (Hawes et al., 1995). Firstly the presence of wandering was ascertained and recorded as; not in the last 7 days, 1-3 or 4-6 times in the last 7 days or every day. If wandering was present the carer was then asked whether the behaviour was easily altered. A maximum of 4 points was given (where wandering was present every day and not alterable).

2.3.4 Neuropsychological measures

One of the aims of this study was to determine the cognitive domains associated with fall risk. Therefore in-depth assessment was necessary to measure function in the following domains; attention and concentration, memory, processing speed, visuo-spatial ability, executive function, language and dual tasking ability. The majority of these domains were tested using the Addenbrooke's Cognitive Examination Revised (ACE-R) (see appendix C). Mini mental examinations (Folstein et al., 1975) conducted in the year prior to data collection and recorded in medical or care records

were used to provide a measure of cognitive function in those who were in the screening study (see appendix C).

2.3.4.1 Measurement of orientation, attention and concentration

2.3.4.1.1 Orientation procedure (ACE-R)

Participants were asked 10 questions to determine their orientation to time and place. Time questions were; day of the week, date, month, season and year. Place questions were; name of the home, floor level, name of the city (London), the borough (i.e. Lambeth/Southwark) and name of the local area (i.e. Peckham). One point was given for each correct answer. In most cases answers were either correct or incorrect. However, if the season was incorrect within 1 week or the location/ borough close enough to be reasonably considered as local, a point was given for these answers. No clues were given to the answers and any prompts such as newspapers removed from sight.

2.3.4.1.2 Registration procedure (ACE-R)

Participants were given the following instructions: “Now I'm going to name three objects. After I have said all three objects, I want you to repeat them. Remember what they are because I am going to ask you to name them again in a few minutes, "lemon, penny, ball". A point was given for each item correctly registered at the end of this instruction.

2.3.4.1.3 Attention and concentration procedure (ACE-R)

The first test for this category was serial 7s. The following instruction was given to the participant, “Now I would like you to subtract 7 from 100, and keep subtracting 7

from each new number until I tell you to stop". Correct responses were given one point and the test continued until the participant had carried out 5 subtractions with a maximum score of 5. Where participant clearly could not perform this test or scored less than 5 points, a further test was carried out. The instructions for this test were as follows; "now I am going to spell a word forwards and I want you to spell it backwards. The word is world W- O- R- L- D. Spell 'World' backwards". Each correct letter identified scored 1 point. The final score for the attention and orientation section was the sum of the "serial 7s" and "WORLD backwards" with a maximum score of 5.

2.3.4.2 Measurement of memory

2.3.4.2.1 Memory recall procedure (ACE-R)

This test was undertaken after the attention and concentration questions to determine whether the three objects named in the registration section could be recalled after a short period. The following instructions were given, "now what were the three objects that I asked you to remember?" One point was given for each correct answer (maximum of 3)

2.3.4.2.2 Anterograde memory (ACE-R)

The participant was given a name and address to remember. It was read to the participant, who repeated it back to the assessor. This was carried out 3 times. The components of the name and address correctly registered on the final repetition were recorded with 2 points for the name (first and surname) and 5 points for the address (house number, street name, town and county). The following instructions were given;

“I 'm going to give you a name and address and I'd like you to repeat it back to me. We'll be doing that 3 times, so you have a chance to learn it as I'll be asking you later.” At the end of the full ACE-R (10-15 minutes later) the participant was asked to recall the name and address they had learnt at the beginning of the test. One point was given for each correct component identified (maximum of 7). If components were not recalled, they were given three possible choices to determine recognition of the correct response. Again, each correct response was given 1 point.

2.3.4.2.3 Retrograde memory procedure (ACE-R)

The participant was asked 4 questions; 1. What is the name of the current prime minister? 2. Who was the only woman to be British prime minister? 3. Who is the president of the United States of America? 4. Can you name the USA president who was assassinated in the 1960s? One point was given for each correct answer. During the study, there was a change in British prime minister and USA president. Participants were still given one point if they identified the previous incumbent until one week after they had left office.

2.3.4.2.4 Logical memory story procedure (Wechsler memory scale revised (WMS-III))

This test measures immediate and delayed recent verbal memory (Wechsler, 1997). The participant was given the following instructions, “I am going to read a short story to you. Listen carefully and try to remember it just the way I say it, as close to the same words as you can remember. When I have finished I want you to tell me everything I read to you. You should tell me all you can remember even if you are not sure.”

The story text is included below and the words recalled by the participant which contributed to each point are underlined. The text was read once.

"Anna Thompson of South Bermondsey, employed as a cook in a school cafeteria, reported at the Police Station that she had been held up on East Street the night before and robbed of fifty-six pounds. She had four small children, the rent was due, and they had not eaten for two days. The police, touched by the woman's story, took up a collection for her."

Participants were asked to remember the story immediately and after 25-30 minutes. Each time the score out of a possible 25 was recorded.

2.3.4.3 Measurement of processing speed

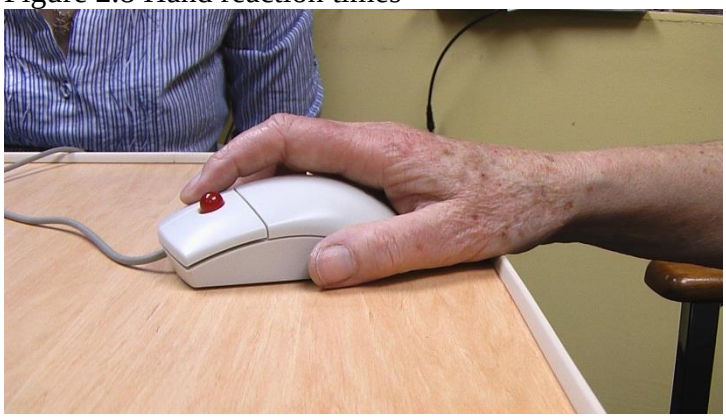
Processing speed was measured using simple hand reaction times and the trails (A) test.

2.3.4.3.1 Simple hand reaction times procedure

Reaction times were measured using an adapted computer mouse with a light as the stimulus and the left mouse button next to the light as the response switch. The timer has a variable delay of between 1 and 5 seconds so the participant was not able to get prompts from the tester as to when to respond. The reaction time was the time taken from the light turning on to the response switch being pressed and was measured in milliseconds. Participants were sat at a table and rested the index finger of their dominant hand on the response switch. They had 5 practice trials and a further 10 reaction times were then recorded. They were given the following instructions "This is a computer mouse. It has a light and a switch. When the light comes on, I would

like you to press the switch as quickly as possible" (Figure 2.8). The mean reaction time of the 10 measured was used in analysis.

Figure 2.8 Hand reaction times

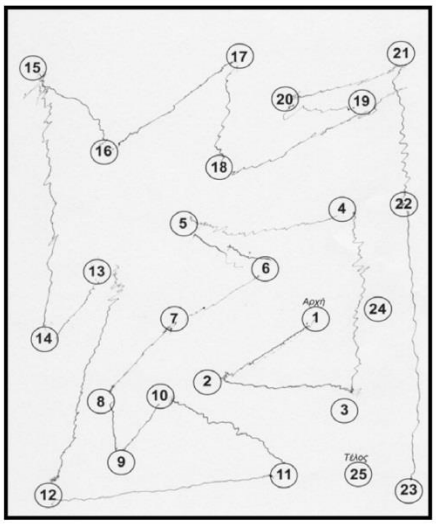


2.3.4.4 Measurement of speed of executive function

2.3.4.4.1 Trail making test – Test A procedure

The trail making test (test A) measures the time taken for a participant to connect 25 numbers in ascending order on a sheet of paper (Bowie and Harvey, 2006). The participant was shown a practice paper to illustrate what was involved in the test.

Figure 2.9 Trails making test A



They were then given the test paper and a pen and instructed "on this page there are more numbers, just like in the practice trial, begin at number one and draw a line from one to two, two to three, three to four and so on until you reach 25. Do this as quickly as you can". The time taken to complete the test was recorded. A cut off score of 300 seconds was used for those who took longer to complete the test or could not understand how to do the test (Figure 2.9).

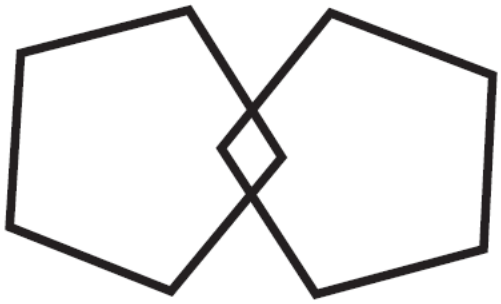
2.3.4.5 Measurement of visuo-spatial function

Visuo-spatial function was measured using components of the ACE-R.

2.3.4.5.1 Overlapping pentagons procedure.

Participants were asked to copy a design of overlapping pentagons. A score of one point was given if each pentagon had five sides and the intersection was present (Figure 2.10).

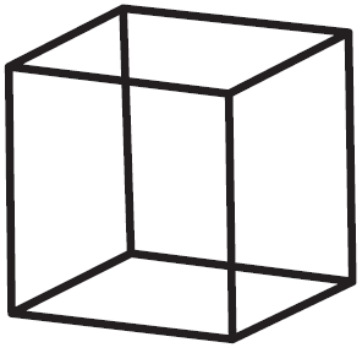
Figure 2.10 Overlapping pentagons



2.3.4.5.2 Cube drawing procedure.

Participants were asked to copy an outline of a cube. A score of 1 was given if most of the sides were included with a basic square shape and a score of 2 if all the lines and the correct perspective were included (Figure 2.11).

Figure 2.11 Cube

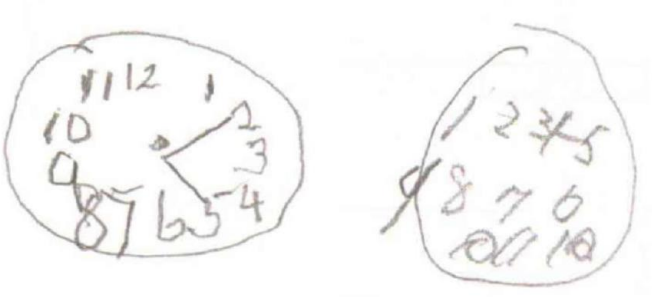


2.3.4.5.3 Clock drawing test procedure.

The participant was first asked to draw a clock face with all the numbers on. Once they had done this, they were then asked to draw the hands at "ten past five". A maximum of 1 point was awarded for a reasonable circle. One point was given if all numbers were included increasing to two points if they were also equally distributed. A maximum of 2 points were given if the hands were on the correct numbers and the correct lengths. Only 1 point was given if the hands were on the correct numbers but

incorrect lengths, one hand was on the correct number and was the correct length or only one hand present was on one of the correct numbers. See Figure 2.12 for examples.

Figure 2.2 Examples of the clock test



5 points (circle, correct numbers and hands)

2 points (circle, correct numbers but not distributed appropriately, no hands)

2.3.4.5.4 Dots and letters

Participants were shown 4 boxes containing varying numbers of dots. They were asked to count how many dots were present in each box without using their finger to point. One point was given for each box correctly counted. The letter test contained incomplete letters. One point was given for each correctly identified letter.

2.3.4.6 Measurement of language

Language measures in the ACE-R and the Boston naming test were used.

2.3.4.6.1 Verbal fluency procedure part 1

Each participant was given the following instructions: “I'm going to give you a letter of the alphabet and I'd like you to tell me as many words as you can beginning with that letter, but not names of people or places. You get 1 minute from when I say the

letter. Are you ready? The letter is P". Words named in 1 minute were recorded and names of people or places, repetitions or words starting with other letters were not counted. Scores range from 0 (<3 correct responses) to 7 (>17 correct responses).

2.3.4.6.2 Verbal fluency procedure part 2

The participants were given the following instructions "Now can you name as many animals as possible, beginning with any letter?" All responses were recorded but only scored if they were not repetitions and did not include both the type of and species that are the same (i.e. fish and salmon). Scores again ranged from 0 (<5 correct responses) to 7 (>21 correct responses).

2.3.4.6.3 Language comprehension procedure part 1

The participant was asked to "read this sentence and do as it says". A card was held up on which the words "close your eyes" were clearly printed. A score of 1 was given for the correct response (closing the eyes).

2.3.4.6.4 Language comprehension procedure part 2

The participant was given the following 3 stage instruction: "Take this piece of paper in your (non-dominant) hand, fold it in half using both hands, and put the piece of paper on the floor". The tester held a piece of paper out for the participant to pick up and 1 point was given for each stage completed (maximum of 3 points).

2.3.4.6.5 Language writing procedure

Participants were asked to write a sentence. A maximum of one point was given for a correct sentence which included a verb, an object and a meaning.

2.3.4.6.6 Language repetition procedure

The participants were asked to repeat the following words, hippopotamus, eccentricity, unintelligible and statistician. A score of 2 was given for correct repetition of all 4 words, 1 was given for three correct responses and 0 for 2 or less. Repetition of two phrases; “no ifs, ands, or buts” and “above, beyond and below” scored one point each if correctly pronounced.

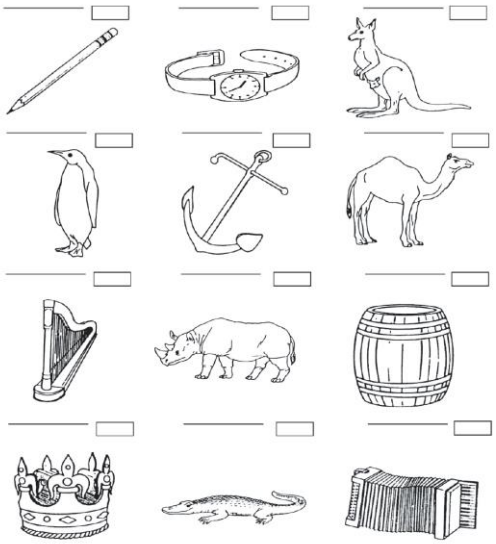
2.3.4.6.7 Language naming procedure

Participants were shown 12 pictures (7 objects and 5 animals) and asked to name them. One point was scored for each picture correctly named (Figure 2.13).

2.3.4.6.8 Language comprehension procedure part 3

The participant was asked to continue looking at the pictures and point to the picture that “is associated with the monarchy”, “has a nautical connection”, “is found in the Antarctic” and “is a marsupial”. One point was given for each correct answer.

Figure 2.13 Pictures for naming and comprehension tests



2.3.4.6.9 Language reading procedure

Participants were asked to read 5 words; sew, pint, soot, dough and height. One point was given if all five were read correctly.

2.3.4.6.10 Boston naming test procedure

The short 15-item version of the Boston Naming test was used (Mack et al., 1992). Participants were shown the pictures in the specified order and given 20 seconds to name the item illustrated. If they were not able to name the item, or gave an incorrect response, a standardised stimulus cue was given for each picture. If the participant could still not correctly identify the item after 20 seconds, a phonetic cue was given (the first consonant and vowel of the word in question). One point was given for each correct answer or answer given after a stimulus cue. No points were given for correct answers following phonetic cueing.

2.3.4.7 Measurement of dual tasking

Dual tasking was measured using the stop walking when talking test (Lundin-Olsson et al., 1997).

2.3.4.7.1 Stops walking when talking procedure

This test was performed either when walking to or from where the assessment took place or on the return leg following the 6 metre walk test. Once walking, participants were engaged in conversation including a question they were expected to answer and it was noted whether they stopped walking to talk.

2.3.5 Falls follow-up

A fall was defined as "an unexpected event in which the participant came to rest on the ground, floor or lower level". Participants were followed for 6 months after baseline assessment. A research assistant visited each participating home at least every two weeks and reviewed formal accident reporting systems and care plans to determine whether any falls had occurred. Time and date of falls as well as the place the fall occurred, the activity taking place at the time and the suspected cause of the fall were recorded. Injuries sustained and resulting treatment was also recorded. Injuries were defined as cuts, bruising, sprains, dislocations, fractures or pain as a consequence of a fall.

2.4 Data analysis

SPSS version 19 and STATA version 12 (StataCorp., 2011) were used for data analysis. Data analysis for individual studies will be described in the relevant chapter.

2.4.1 Preparing data for analysis

2.4.1.1 Dealing with missing data

Missing data analysis was only necessary for the detailed study (chapter 4). Missing data were counted and coded for analysis. Random missing data are defined as data missing due to refusals to take part or incorrect data inputting. The other important source of missing data was if a participant was unable to complete a test either for physical or cognitive (understanding/attention/orientation) reasons. It was important to code these data appropriately as being unable to perform a particular test could be an indicator on the spectrum of the particular function being measured (e.g. being

unable to perform a 6 metre walk due to limited mobility). Data were coded differently as to whether it was a physical or a cognitive impairment that prevented participation and also depended on the domain tested. Where a neuropsychological test could not be completed due to the extent of the cognitive impairment, the participant was given a score equivalent to 3SDs worse than the average for the dataset. This was also the case where a physical test could not be completed due to physical impairment. Where a physical test could not be completed due to cognitive difficulties (i.e. inability to understand instructions for a balance test) or a cognitive test due to physical difficulties (i.e. naming pictures when blind), the expectation-maximisation algorithm (EM) was used to calculate a score (Dempster et al., 1977). To calculate EM, all variables were first analysed for correlations. The four variables with the strongest correlation were used to calculate EM in each variable using SPSS. The EM method was also used for random missing data. The missing data requiring use of EM method were calculated first. Following this, where tests could not be completed because a participant was too impaired, a score of 3 standard deviations below the variable mean was calculated and inputted (Table 2.3).

Table 2.3 Dealing with missing data

Type of missing data	**Method for dealing with data**
Random missing data (refusal, incomplete records)	EM method
Physically incapable of performing a sensori-motor, balance or gait test	3SD below mean
Physically incapable of performing a mood / neuropsychological test	EM method
Cognitively incapable of performing a sensori-motor, balance, gait or mood test	EM method
Cognitively incapable of performing a neuropsychological test	3SD below mean

2.4.1.2 Ensuring a normal distribution

Each of the variables were analysed using descriptive statistics for normality. Variables with a skew of more than +1 or -1 were deemed to be skewed and positively skewed data was log transformed using Lg10 calculation in SPSS. The above descriptive statistics were then repeated to determine whether the skew was improved. If this was satisfactory, log transformed skewed data was used in parametric data analysis. If log transformation did not improve distribution, non-parametric data analysis was used for those variables.

2.4.1.3 Determining faller status

Those who had fallen one or more times in the six month follow up were classified as fallers and those who did not fall were classified as non-fallers. Those who fell two or more times were classified as multiple fallers and those who fell once or not at all were non-multiple fallers.

2.4.1.4 Determining follow up status

There are many possible reasons why participants fail to complete the 6 month falls follow up. Failure to achieve follow up is not independent of faller status as a fall resulting in injury may result in hospitalisation, change of care requirements or even death.

Participants with less than 75% follow up (<4 months) from analysis of faller status were excluded unless they had sustained a fall prior to loss to follow up.

2.4.2 Reliability data

The first 11 participants who took part in detailed data collection agreed to repeated data collection 2-3 weeks following this initial assessment. The same tester (Julie Whitney) conducted all the tests. To reduce bias, test results were instantly entered into the study database and not referred to before the second testing period.

Test-retest reliability was analysed using firstly by looking at differences between the first and second measurement. This was done using 95% confidence intervals of the mean difference and paired t tests.

The SEM was used to assess the variability of individual scores and reflected the units used in each test (Weir, 2005) and was calculated using square root of the mean square error from the two way ANOVA. The %SEM was calculated using the following equation: $SEM\% = \left(\frac{SEM}{mean\ from\ test\ 1\ and\ test\ 2}\right) x100.$

Finally intraclass correlation coefficients (2,1) were used to determine relative reliability. All data analysis was conducted using SPSS version 19. Data are presented in Table 2.4 .

Table 2.4 Reliability data

Test (score / unit)	Mean 1 (SD)	Mean 2 (SD)	Mean difference (95%CI)	T test (df)	Sig	SEM (%SEM)	ICC (95%CI)
Melbourne edge test (0-20)	14.5 (3.4)	14.5 (4.4)	0 (-2.5-2.5)	0 (9)	1.0	2.5 (17)	0.59 (-0.02-0.88)
Hand reaction time (msecs)	344 (99)	447 (347)	-103(-319-113)	-1.08 (9)	0.31	212 (54)	0.31 (-0.36-0.77)
Knee extension strength (Kgs)	12.9 (7.0)	13.8 (6.7)	-0.9 (-3.9-2.1)	-0.71 (9)	0.49	2.8 (21)	0.83 (0.46-0.96)
Grip strength (Kgs)	8.2 (4.4)	8.7 (4.4)	-0.5 (-1.7-0.7)	-0.93 (9)	0.37	1.2 (14)	0.92 (0.73-0.98)
Proprioception (degrees)	3.1 (2.3)	3.3 (1.5)	-0.24 (-1.8-1.4)	-0.33 (9)	0.75	1.6 (50)	0.29 (0.38-0.76)
Sway on floor eyes open (mm^2)	471 (331)	1005 (1294)	-535 (-1384-314)	-1.46 (9)	0.19	731 (99)	0.40 (-0.36-0.84)
Sway on floor eyes closed (mm^2)	948 (1217)	956 (647)	-8.57 (-1010-992)	-0.02 (6)	0.98	766 (70)	0.38 (-0.45-0.86)
Timed up and go (seconds)	65.4 (63.2)	59.6 (38.4)	5.9 (-19-31)	0.54 (8)	0.61	23 (37)	0.80 (0.34-0.95)
Six metre walk (seconds)	25.6 (28.8)	25.0 (24.5)	0.56 (-3.4-4.6)	0.32 (8)	0.76	3.7 (15)	0.98 (0.92-1.0)
Sit to stand score (1-4)	3 (0.82)	3 (0.82)	0	0 (9)	1.0	0 (0)	1.0
Balance score (0-5)	1.98 (1.11)	1.97 (1.13)	0.10 (-0.4-1.5)	0.05 (9)	0.98	0.4 (20)	0.86 (0.54-0.96)
Goldberg Anxiety Scale (0-9)	2.0 (2.1)	2.1 (2.2)	-0.1 (-1.5-1.3)	-0.17 (9)	0.87	1.4 (70)	0.60 (0.002-0.88)
Geriatric depression Scale (0-15)	3.8 (3.7)	3.1 (2.5)	0.7 (-0.7-2.1)	1.1 (9)	0.3	1.4 (40)	0.80 (0.38-0.95)
ACE-R (0-100)	45.5 (11.0)	41.1 (12.3)	4.4 (0.3-8.5)	2.4 (10)	0.04	4.2 (10)	0.87 (0.59-0.96)
Logical memory story (0-25)	3.9 (2.2)	1.9 (2.1)	2.0 (1.1-2.9)	5.1 (9)	0.001	0.9 (31)	0.83 (0.45-0.96)
Boston naming test (0-15)	8.2 (3.9)	6.9 (3.6)	1.3 (0.4-2.2)	2.9 (9)	0.02	1.0 (13)	0.93 (0.74-0.98)

Analysis of the reliability data identified a significant deterioration of cognitive function between the first and second tests. When individual data was examined this was not due to one or two participants, but small changes across the group. All other scores were not significantly different as indicated by t-tests and 95% confidence intervals of the mean of the difference. There were high levels of within participant variability in the postural sway and Goldberg anxiety measures indicated by a high %SEM. The intraclass correlations between first and second measures indicated that there was excellent reliability in the tests of strength (knee extension and grip), gait (timed up and go and 6 metre walk), balance scores, depression (Geriatric depression scale) and cognition (ACE-R, logical memory story and Boston naming test). The Melbourne edge test and Goldberg anxiety scale had fair reliability and hand reaction times, proprioception and sway measures poor reliability. These results strongly indicate there was no learning effect from undertaking the tests twice and they even identify the decline in cognition which may be expected in a population with dementia but surprising considering the short time period between tests. Variability in some of the tests may be due to fluctuations in performance associated with cognitive impairment and dementia. This will be considered when forming conclusions on the data, as the benefits of using the mean of two different tests would be unlikely to outweigh the additional time and resources required to conduct such tests. There was no learning effect and therefore there was no need to look for plateau effects to identify "true" function.

Defining Falls Risk Factors in Older Adults with Cognitive Impairment Living in Residential Care

Chapter 3

Identification of high risk fallers among older people living in residential care facilities

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3 Identification of high risk fallers among older people living in residential care facilities: a simple screen based on easily collectable measures

3.1 Introduction

Falls are of particular concern in residential and nursing homes, where rates are significantly higher than in community dwelling populations (Becker and Rapp, 2010). The rate of fall-related injury is also high with residents from such institutions contributing to 20% of all hip fracture hospital admissions in the UK (Morgan et al., 2004).

Approximately 75% of those living in residential care facilities have mobility disability (Sackley et al., 2009) and at least half have cognitive impairment (Matthews et al., 2002). Previous studies have identified a number of important risk factors for falls in this setting including impaired cognition, unsteady gait, poor balance, behavioural disturbances and use of psychotropic medications (Thapa et al., 1995, van Doorn et al., 2003, Luukinen et al., 1995c).

Interventions to prevent falls in residential care facilities have produced equivocal outcomes. Findings from single interventions indicate that vitamin D supplementation and medication review are effective but that exercise as a stand-alone intervention does not prevent falls in this group (Cameron et al., 2010). Some multi-factorial interventions have been effective (Becker et al., 2003), although when all trials are considered, there is no evidence for significant reductions in falls or fallers (Cameron et al., 2010). In order to implement

effective interventions in a targeted manner, those at high risk of falls need to be readily identifiable, preferably using a simple screen and/or routinely collected measures.

Several studies have designed fall risk assessment tools for those living in residential care. However, in many cases data were not collected for all relevant domains. For example, studies have included physical function assessments only (Lundin-Olsson et al., 2000, Lundin-Olsson et al., 2003, Nordin et al., 2008), excluded measures of behaviour (Barker et al., 2008, Rosendahl et al., 2003) or analysed fall risk in resident sub-groups depending on mobility, consequently increasing the complexity of the resultant screening tools (Barker et al., 2008, Becker et al., 2005, Delbaere et al., 2008).

To address this issue, a large prospective study was conducted to quantify the relative contributions of easy to measure and routinely available fall risk factors in older people living in residential care in order to design a falls risk screen.

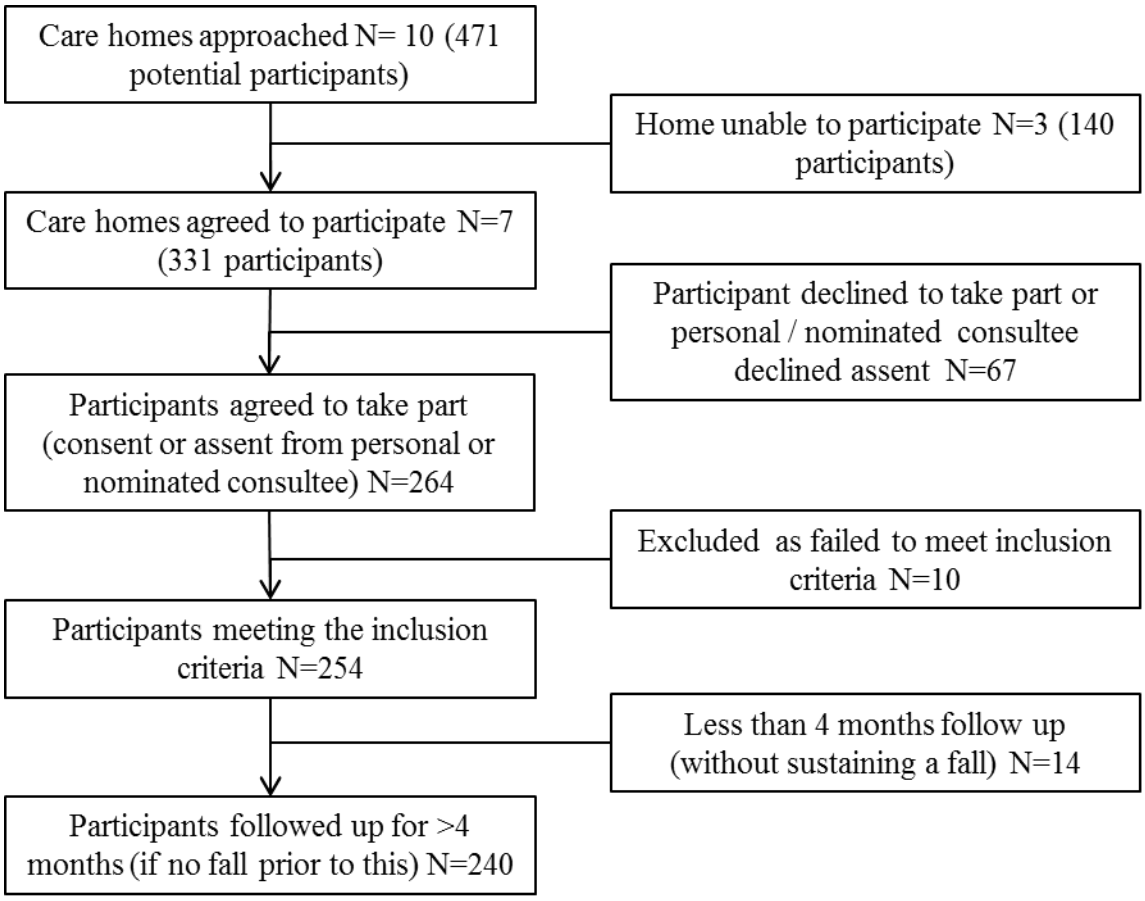
3.2 Methods

3.2.1 Participants

Initially, 10 residential care homes in South London, U.K. were invited to participate in the study and of these seven (two of which housed nursing care units) agreed to do so. Permanent residents of these facilities were then approached to take part (see

Figure 3.1). Inclusion and exclusion criteria are described in chapter 2. Cognitively intact participants were not excluded from this study as the aim was to design a fall risk screening tool applicable to all care home residents. Informed consent for participation in the study was obtained from the participants or from legal carers. The South London and Maudsley and Institute of Psychiatry joint ethics committee approved the study.

Figure 3.1 Flow chart for recruitment to the study



3.2.2 Risk factor data collection

Information was collected from care records, medical notes and by questioning carers with no active involvement from the participants. Carers providing information were key workers, team leaders or a carer who knew the participant well. All information was collected within a 2 week period prior to commencement of prospective falls data collection. Detailed descriptions of methods used are provided in chapter 2.

Demographics, medical history, falls in the previous year and walking aids used were recorded from medical and care records. Prescription charts were used to determine medication use. Medications were coded using British National Formulary (BNF) codes. The

mini-mental state examination (MMSE) (Folstein et al., 1975) was used to measure cognitive function. MMSE scores recorded in medical or care notes within the year prior to data collection were used. Functional ability was measured using the Barthel Index (Mahoney and Barthel, 1965). Carers were asked to rate the sit-to-stand ability and standing balance ability using the scales detailed in chapter 2. Behaviour was measured using the neuro-psychiatric inventory (NPI) (Cummings et al., 1994). Wandering was measured using the wandering item from the Minimum Data Set Version 2 (behavioural symptoms). To measure impulsivity in mobility, the falls related impulsive behaviour scale was used (chapter 6).

3.2.2.1 Falls surveillance

Falls data were collected as described in chapter 2.

3.2.3 Data analysis

Chapter 2 provides information on methods used to normalise skewed data.

3.2.3.1 Power calculation

A priori power analyses (with significance levels of 0.05 and power of 0.8), using data from previous population studies indicated a sample size of 200 would allow for a minimum of 10 outcome cases (fallers) for up to 10 variables entered into multivariate models and be adequate for determining significant differences between faller and non-faller groups (Concato et al., 1993). .

3.2.3.2 Univariate analysis

After dealing with missing data, descriptive statistics were calculated for all the data collected and were analysed for relationships between them using correlation coefficients.

3.2.3.2.1 Faller status

Continuous data were analysed using t-tests or Mann-Whitney tests (as indicated by the data) to identify significant differences between fallers (≥1 falls) and non-fallers and multiple fallers (≥2 falls) and non-multiple fallers (≤1 falls). A significant difference between fallers and non-fallers was indicated by a p value of <0.006 when the Bonferroni adjustment for the number of continuous variables analysed was used.

Scales with multiple components were broken down and each section compared using t-tests of Mann-Whitney tests.

Categorical data were analysed for differences in faller status using Chi square tests and dichotomous data analysed using Chi square and relative risks. This included the effect of care home on faller status.

Non-linear relationships

Graphs were used to identify non-linear relationships between categorical scores or score quartiles and faller status.

3.2.3.3 Multivariate analysis

3.2.3.3.1 Faller status

To achieve the aim of creating a simple falls risk screen where cut-points can be used to identify an appropriate level of dysfunction in a particular test, continuous data were dichotomised by calculating the optimal specificity and sensitivity for falls using the Youden

index (Ruopp et al., 2008). Dichotomous and dichotomised data were then entered into forward binary logistic regression analysis to find the best set of significant and independent predictors of being a faller. Since the univariate analysis demonstrated that variables were more different between fallers and non-fallers rather than between multiple and non-multiple fallers, being a faller (having ≥1 fall) was the dependent variable. Discrimination (the ability of a model to distinguish high-risk residents from low-risk residents) was quantified using the area under the receiver-operating characteristic curve (AUC) (Harrell et al., 1996). The AUC for the weighted model (using the independent and significant variables from logistic regression) was compared to the AUC for the unweighted model (number of risk factors present) using the rocomp command in STATA. To compare the relative goodness of fit of these two models, the Akaike information criterion (AIC) was used (Anderson, 2007).

3.2.3.3.2 Falls rates

The dichotomised continuous data identified using the youden index and the dichotomous data were used to investigate the relationship between baseline variables and falls rates. This was analysed using univariate and multivariate incident rate ratios calculated using negative binomial regression analysis and adjusting for follow up time.

3.3 Results

3.3.1 Recruitment

3.3.1.1 Care homes

Ten care homes were approached to take part in this study. The number of potential participants living in these homes amounted to 471. Details of the homes are included in Table 3.1. Of these homes, seven agreed to take part. Of the homes that did not participate,

one care home cited commitments to another research project and building works. In the second, the recently appointed new manager felt the home had too many challenges to face to take part and the final care home asked for the head office of the company to give permission and although this was sought and the matter followed up, no reply either way was ever provided.

3.3.1.2 Individual participants

A total of 331 participants were approached to take part in the study. Of these 264 were recruited (153 consented to take part and we received assent from the relatives or carers of 111). Ten participants were then excluded for failing to meet the inclusion / exclusion criteria leaving a total of 254 participants who underwent baseline assessment. Reasons for exclusion from the study included; being aged <60 (n=3), recent hospital admission (n=1), end stage illness (n=1) and being fully bedbound (n=5). Two hundred and forty of the participants from whom baseline measures were taken had at least 4 months of falls follow up data or had fallen prior to loss of follow up. Reasons for loss of follow up (without prior fall) included death (n=7), admission to hospital for the remaining time (n=4), transfer to nursing care (n=1) and return home (n=2) (see Figure 3.1).

Table 3.1 Information on care homes approached

Home number	Type of care (registered care categories)	Care Quality Commission rating (at the time of participation)	Number of beds (% recruited)	Took part (if not why)
1	Residential (dementia, older people)	3 stars (Excellent)	48 (73%)	Participated
2	Residential (dementia, older people)	2 stars (Good)	48 (79%)	Participated
3	Residential (dementia, older people)	1 star (adequate)	48 (63%)	Participated
4	Residential care home with nursing (dementia, older people, physical disability)	Not yet rated	60 [30 nursing] (75%)	Participated
5	Residential care (dementia, older people)	2 stars (good)	27 (77%)	Participated
6	Residential care (older people)	2 stars (good)	28 (61%)	Participated
7	Residential care with nursing (dementia, older people)	3 stars (excellent)	88 [24 nursing] (61%)	Participated
8	Residential care with nursing (dementia, older people, physical disability)	1 star (adequate)	55	Declined (due to new manager)
9	Residential care with nursing (dementia, older people)	1 star (adequate)	60	Declined (failed to reply to correspondence)
10	Residential care (dementia, older people)	2 stars (good)	25	Declined (building work and other research)

3.3.2 Baseline data

3.3.2.1 Demographics

The mean age was 83.7 (SD 8.6) ranging from 61-107. One hundred and fifty four (63%) were female and most, 83%, were Caucasian (Caribbean=8%, African=5% Mediterranean=2%, Asian =1% and other=1%). Sixty eight percent of participants were born in the UK (9% Ireland, 6% Jamaica, 3% other European countries, 3% Africa, 1% Asia and 10% other or missing data). This was reflected in the fact that 75% spoke English as a first language. Table 3.2 provides demographic and baseline information for each care home.

Table 3.2 Baseline data for each care home

Care home	**1 (N=35)**	**2 (N=38)**	**3 (N=30)**	**4 (N=16) (residential)**	**4 (N=29) (nursing)**	**5 (N=21)**	**6 (N=17)**	**7 (N=20) (residential)**	**7 (N=23) (EMI)**	**7 (N=11) (nursing)**	**Total (N=240)**
Age (SD)	83.4 (8)	83.8 (9)	85.7 (9)	81.8 (10)	77.7 (8)	88.1 (8)	88.2 (7)	82.0 (7)	84.6 (7)	84.0 (9)	83.7 (9)
% Female	60%	76%	73%	75%	41%	57%	71%	75%	52%	64%	64%
% Caucasian	91%	90%	87%	88%	66%	91%	100%	85%	70%	46%	83%
MMSE (SD)	13.5 (8)	14.5(5)	13.2 (6)	7 (5)	10 (7)	15.0 (7)	18.5 (7)	17.3 (7)	13.3 (8)	13.1 (6)	13.5 (7)
Barthel (SD)	61 (28)	65 (23)	62 (26)	63 (18)	33 (24)	55 (26)	56 (23)	71 (16)	67 (20)	22 (14)	57 (26)
NPI (SD)	18 (20)	13 (17)	11 (12)	23 (18)	33 (23)	19 (18)	21 (13)	9 (13)	16 (13)	23 (16)	18 (18)
Impulsivity (SD)	5.7 (4)	5.3 (3)	5.5 (4)	5.8 (2)	6.7 (4)	5.7 (5)	4.8 (2)	3.7 (2)	4.4 (3)	3.7 (1)	5.3 (3)
STS (SD)	2.8 (0.8)	2.8 (0.7)	2.7 (0.5)	3.0 (0.4)	2.4 (0.9)	2.7 (0.6)	2.7 (0.7)	3.0 (0.2)	2.9 (0.3)	2.2 (0.8)	2.7 (0.7)
Balance (SD)	4.3 (1)	4.2 (1)	4.1 (1)	5.1 (1)	3.7 (2)	4.5 (2)	3.9 (1)	4.7 (1)	4.9 (1)	2.8 (1)	4.3 (1)
No of medications (SD)	8 (3)	8 (3)	7 (3)	8 (4)	8 (3)	7 (4)	7 (3)	7 (4)	6 (3)	8 (4)	7 (4)
No of medical conditions (SD)[1]	1.6 (1)	1.5 (1)	1.3 (1)	1.2 (1)	1.6 (1)	1.4 (1)	2.3 (1)	2.0 (1)	1.0 (1)	2.7 (1)	1.6 (1)

[1] = Conditions summed if present = stroke, hypertension, diabetes, arthritis, Parkinson's disease, previous hip fracture and depression

3.3.2.2 Medical factors

3.3.2.2.1 **Medical conditions**

The conditions identified are listed using ICD10 classification in Table 3.3. The most common conditions were urinary incontinence (55%), hypertension (40%), arthritis (37%), diabetes (23%), stroke (23%) and depression (20%). Most of the participants had evidence of cognitive impairment, although only 30% had a diagnosis which included a cause with the remaining either having a diagnosis of unspecified dementia (33%) or no diagnosis but clear signs of cognitive impairment manifest in behaviour or mini mental state examination (25%) (Table 3.4). Medical conditions associated with increased falls risk including stroke, hypertension, diabetes, arthritis, Parkinson's disease, previous hip fracture and depression were summed with a mean of 1.6 (1.2 SD) (range 0-5) of these conditions.

Table 3.3 Reported medical conditions

Condition (recorded in care or medical notes) Using ICD10 classification	**Number of participants**	**% of sample**
I. Certain infectious and parasitic diseases		
Previous TB	5	2%
II. Neoplasms		
Any cancer diagnosis	26	11%
III. Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism		
Anaemia	22	10%
IV. Endocrine, nutritional and metabolic diseases		
Diabetes	56	23%
Hypercholesteraemia	26	11%
Thyroid dysfunction	32	13%
V. Mental and behavioural disorders*		
Depression	47	20%
Schizophrenia	13	5%
Hallucinations	3	1%
Other mental health problems	18	8%
Learning difficulties	2	1%
VI. Diseases of the nervous system		
Epilepsy	13	5%
Parkinson's disease	11	5%
VII. Diseases of the eye and adnexa		
Cataracts	34	14%
Macular degeneration	14	6%
Glaucoma	11	5%

Condition (recorded in care or medical notes) Using ICD10 classification	**Number of participants**	**% of sample**
Other eye condition	5	2%
VIII. Diseases of the ear and mastoid process		
Diagnosed hearing impairment	12	5%
IX. Diseases of the circulatory system		
Hypertension	97	40%
Angina	13	5%
Myocardial infarction	14	6%
Ischaemic heart disease	14	6%
Heart valve dysfunction / repair	6	3%
Atrial fibrillation	23	10%
Cardiac arrhythmias	8	3%
Congestive cardiac/left ventricular failure	10	4%
Stroke	54	23%
Aortic aneurysm / repair	2	1%
Pacemaker	*10*	*4%*
X. Diseases of the respiratory system		
COPD	16	7%
Other respiratory problems	8	3%
XI. Diseases of the digestive system		
Liver disease	6	3%
Constipation	17	7%
Other disease / surgery of digestive system	36	15%
XII. Diseases of the skin and subcutaneous tissue		
Cellulitis	2	1%
Leg ulcers / pressure sores	12	5%
Other skin conditions	8	3%
XIII. Diseases of the musculoskeletal system and connective tissue		
Arthritis	89	37%
Joint replacement	*13*	*5%*
Osteoporosis	26	11%
XIV. Diseases of the genitourinary system		
Urinary incontinence	131	55%
Gynae condition / gynae surgery	1	0.5%
Prostrate problems	11	5%
XVIII. Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified		
Syncope / collapse	4	2%
XIX. Injury, poisoning and certain other consequences of external causes		
Hip#	24	10%
Other lower limb #	10	4%
Upper limb #	14	6%
XXI. Factors influencing health status and contact with health services		
Alcohol misuse	20	8%

*dementia diagnoses not included in this table – see Table 3.4 for details.

Table 3.4 Causes of cognitive impairment

Diagnosis	Number	Frequency
Alzheimer's disease	21	9%
Vascular dementia	25	10%
Mild cognitive impairment	7	3%
Alcohol related	6	2.5%
Stroke related cognitive impairment	5	2%
Lewy body dementia	1	0.5%
Dementia (cause not specified)	80	33%
No dementia diagnosis (but clinically cognitively impaired)	60	25%
Mixed aetiology	11	5%
Other dementias	3	1%
Residents without cognitive impairment	21	9%

3.3.2.3 Falls in the previous year

All falls either recorded in care home documents or as an explicit reason for admission to the care home (if the participant resided for <1 year) were noted. One hundred and seventy one (71%) participants had had at least one fall in the previous year. There were a total of 375 falls recorded ranging between 1 and 15 falls per person per year (mean = 2). Of the fallers most (54%) had only one fall.

3.3.2.4 Medications

The most commonly prescribed medications were antiplatelet drugs (50%), non-opioid analgesia (45%), lipid regulating drugs (36%), proton pump inhibitors (35%), stimulant laxatives (33%) and osmotic laxatives (35%). Just over one third (34%) of participants were prescribed calcium and vitamin D supplements and 19% bisphosphonates (Table 3.5). Participants were prescribed a mean of 7 (3.5) medications, ranging between 0 and 18.

Table 3.5 Medication use

Medication (using BNF code)	**Number of participants**	**% of sample**
1. Gastro-intestinal system		
1.1.2. Compound alginates	8	3%
1.2. Antispasmodics	1	0.5%
1.3.1. H^2 receptor agonists	1	0.5%
1.3.4. Prostaglandin analogues	1	0.5%
1.3.5. Proton pump inhibitors	83	35%
1.4.2. Anti motility drugs	5	2%
1.6.1. Bulk forming laxatives	8	3%
1.6.2. Stimulant laxatives	78	33%
1.6.4. Osmotic laxatives	83	35%
1.9.1. Drugs affecting biliary composition and flow	1	0.5%
2. Cardiovascular system		
2.1.1. Cardiac glycosides	19	8%
2.2.3. Potassium-sparing diuretics and aldesterone antagonists	2	1%
2.2.4. Potassium-sparing diuretics with other diuretics	11	5%
2.2.1. Thiazides and related diuretics	35	15%
2.2.2. Loop diuretics	48	20%
2.3.2. Drugs for arrhythmias	1	0.5%
2.4. Beta-adrenoceptor blocking drugs	27	11%
2.5.4. Alpha-adrenoceptor blocking drugs	7	3%
2.5.5.1. Angiotensin-converting enzyme inhibitors	54	23%
2.5.5.2. Angiotension-II receptor antagonists	9	4%
2.6.1. Nitrates	9	4%
2.6.2 Calcium channel blockers	49	20%
2.6.3. Other antianginal drugs	1	0.5%
2.8.1. Parenteral anticoagulant	1	0.5%
2.8.2. Oral anticoagulants	2	1%
2.9. Antiplatelet drugs	119	50%
2.11. Antifibrinolytic drugs and haemostatics	2	1%
2.12. Lipid regulating drugs	86	36%
Midodrine (no classification)	*13*	*5%*
3. Respiratory system		
3.1.1.1. Selective B^2 agonists	17	7%
3.1.2. Antimuscarinic bronchodilators	7	3%
3.1.3. Theophylline	2	1%
3.2. Corticosteroids	14	6%
3.4.1. Antihistamines	8	3%
3.7. Mucolytics	1	0.5%
3.9.1. Cough suppressants	1	0.5%
3.9.2. Demulcent and expectorant cough preparations	1	0.5%
4. Central nervous system		
4.1.1. Hypnotics	18	8%
4.1.2. Anxiolytics	7	3%
4.2.1. Antipsychotic drugs	45	19%
4.2.2. Antipsychotic depot injections	1	0.5%
4.2.3. Antimanic drugs	3	1%
4.3.1. Tricyclic and related antidepressants	13	5%
4.3.3. Selective serotonin re-uptake inhibitors	50	21%
4.3.4. Other antidepressant drugs	17	7%
4.6 Drugs used in nausea and vertigo	2	1%
4.7.1. Non opioid analgesics	109	45%
4.7.2. Opioid analgesics	19	8%
4.8.1. Control of epilepsy	29	12%

Medication (using BNF code)	Number of participants	% of sample
4.8.2. Drugs used in status epilepticus	1	0.5%
4.9.1. Dopaminergic drugs used in Parkinson's disease	11	5%
4.9.2. Antimuscarinic drugs used in parkinsonism	1	0.5%
4.11. Drugs for dementia	10	4%
5. Infections		
5.1.1.2. Penicillinase resistant penicillins	2	1%
5.1.2.1. Cephalosporins	2	1%
5.1.5. Macrolides	1	0.5%
5.1.8. Sulphonamides and trimethoprim	3	1%
5.1.9. Antituberculosis drugs	1	0.5%
5.2. Antifungal drugs	5	2%
6. Endocrine system		
6.1.1.2. Intermediate and long acting insulins	10	4%
6.1.2.1. Sulphonylureas	19	8%
6.1.2.2. Biguanides	16	7%
6.2.1. Thyroid hormones	29	12%
6.2.2. Antithyroid drugs	2	1%
6.3.2. Glucocorticoid therapy	4	2%
6.4.2. Male sex hormones and antagonists	5	2%
6.6.2. Bisphosphonates and other drugs affecting bone metabolism	45	19%
7. Obstetrics, gynaecology and urinary-tract disorders		
7.4.1. Drugs for urinary retention	10	4%
7.4.2. Drugs for urinary frequency, enuresis and incontinence	8	3%
8. Malignant disease and immuosuppression		
8.3.4.1. Hormone antagonists in breast cancer	4	2%
8.3.4.2. Gonadorelin analogues and gonadotrophin-releasing hormones	3	1%
9. Nutrition and blood		
9.1.1.1. Oral iron	42	18%
9.1.2. Drugs used in megaloblastic anaemias	28	12%
9.2.1.2. Oral sodium and water	2	1%
9.5.1.1. Calcium supplements	2	1%
9.6.2. Vitamin B	28	12%
9.6.3. Vitamin C	3	1%
9.6.4. Vitamin D (and calcium)	81	34%
9.6.7. Multivitamin preparations	12	5%
10. Musculoskeletal and joint diseases		
10.1.1. Non-steroidal anti-inflammatory drugs	5	2%
10.1.4. Gout and cytotoxic-induced hyperuricaemia	3	1%
10.2.2. Skeletal muscle relaxants	2	1%
10.3.2. Rubefacients and other topical antirheumatics	10	4%
11. Eye		
11.3.1. Antibacterials	4	2%
11.4.1. Corticosteroids	1	0.5%
11.4.2. Other anti-inflammatory preparations	2	1%
11.5 Mydriatics and cycloplegics	1	0.5%
11.6 Treatment of glaucoma	13	5%
11.8.1. Tear deficiency, ocular lubricants and astringents	6	3%
12. Ear, nose and oropharynx		
12.1.3. Removal of ear wax	6	3%
12.2.1. Drugs used in nasal allergy	2	1%
12.2.3. Nasal preparations for infection	2	1%
13. Skin		

Medication (using BNF code)	Number of participants	% of sample
13.2.1. Emollients	54	22%
13.2.2. Barrier preparations	17	7%
13.3. Topical local anaesthetics and antipuritics	1	0.5%
13.4. Topical corticosteroids	5	2%
13.5.2. Preparations for psoriasis	2	1%
13.9. Shampoos and other preparations for scalp and hair conditions	6	3%
13.10.1.2. Antibacterial preparations also used systemically	5	2%
13.10.2. Antifungal preparations	3	1%
13.11.1. Alcohols and saline	2	1%
13.11.2. Chlorhexidine salts	1	0.5%

3.3.2.5 Barthel

The mean Barthel score was 57/100 reflecting moderate functional impairment. Only 2% of participants were independent in every section of the Barthel. Most residents (82%) were independent feeding while only 15% were independent bathing and 3% on stairs. Most of the residents could transfer independently (70%) and over half walked independently (64%) (Table 3.6**).**

Table 3.6 Breakdown of the Barthel scores

Barthel N=240	Mean (SD)	Median	Range	% independent
Total score /100	57.3 (26) (skew= -0.5(0.2)	65	0-100	2%
Feeding /10	8.9 (2.5)	10	0-10	82%
Bathing /5	0.8 (1.8)	0	0-5	15%
Grooming /5	1.3 (2.2)	0	0-5	25%
Dressing /10	3.9 (4.4)	0	0-10	30%
Bowels /10	6.8 (4.2)	10	0-10	60%
Bladder /10	5.5 (4.5)	5	0-10	45%
Toilet use /10	6.3 (4.4)	10	0-10	55%
Transfers /15	12.5 (4.4)	15	0-15	70%
Mobility /15	11.0 (6.1)	15	0-15	64%
Stairs /10	0.3 (1.7)	0	0-10	3%

3.3.2.6 Balance and function

3.3.2.6.1 Care staff balance question

The mean standing balance score was 4.3 (±1.4), equivalent to requiring a walking aid to maintain balance. Scores ranged from 1-6. Most participants (40%) required the use of a walking aid to maintain standing balance while only 10% were judged to be steady without a walking aid.

3.3.2.6.2 Care staff sit to stand question

The mean sit to stand score was 2.7 (±0.7), equivalent to being able to stand from a chair using arms. Scores ranged from 1-4. Most (71%) participants were able to stand using their arms to help them but 17% required assistance and 7% were unable to stand up even with help.

3.3.2.7 Behaviour, mood and affect measures

3.3.2.7.1 Impulsivity and wandering

The single question to determine whether a resident was impulsive or not, identified 25% as impulsive. The individual questions found evidence of impulsivity when sitting down on the chair/bed/toilet in 26%, before standing up in 17% and walking without help when asked not to in 18%. Twenty seven percent of the participants demonstrated some wandering behaviours with 28 (12%) wandering on a daily basis which was not alterable by care staff (Table 3.7).

Impulsivity scores were highly skewed (skew score=1.95 SE 0.16) which was not improved with log transformation (logged data skew score=0.98).

Table 3.7 Impulsivity and wandering questions

Impulsivity / wandering question	Mean score (SD)	N (%)	
1. Does …….. tend to be impulsive when moving around? *[Impulsive means – rushes to carry out an activity without thinking about it first]*	-	Yes	60 (25%)
2. These are examples of impulsive behaviours could you tell me if …….. has demonstrated any of these behaviours?			
a. Trying to sit down before getting right up to the seat / toilet / bed	1.5 (1.1)	Very frequently Frequently Often Occasionally	14(6%) 9 (4%) 6 (3%) 30 (13%)
b. Attempting to stand before wheelchair footplates have been moved/ brakes applied /frame placed in front	1.4 (1.0)	Very frequently Frequently Often Occasionally	9 (4%) 7 (3%) 5 (2%) 24 (10%)
c. Trying to walk without help when they have been asked not to?	1.4 (1.0)	Very frequently Frequently Often Occasionally	10 (4%) 8 (3%) 7 (3%) 19 (8%)
3. Wandering score	0.7 (1.4)	-	
Total score	5.3 (3.4)	-	

3.3.2.7.2 Neuropsychiatric inventory

Most (86%) of the participants demonstrated behavioural issues on the neuropsychiatric inventory. The mean score was 17.9 (SD 18.2) suggesting most problems were mild. In fact the maximum score reached by any participant was 89 out of a possible 144 points. The most common behaviours exhibited were irritability, agitation, anxiety and depression which affected nearly half the participants. Whereas elation and appetite problems were relatively rare affecting only 15% of residents (Table 3.8**).**

Due to the predominance of low scores the distribution of these data were positively skewed with a skew score of 1.3 (SE 0.16). Log transformation did not improve the distribution of the data with a skew score of transformed data of -1.1 (SE 0.16).

Table 3.8 Breakdown of Neuropsychaitric Inventory

Category	Mean score (SD)	No with identified problem (%)	Mean score of those with this behaviour	Proportion in each category* (out of total sample)	
Delusions	0.96 (2.48)	61 (25%)	3.8 (3.7)	Minor	17%
				Mod	5%
				Severe	4%
Hallucinations	0.88 (2.44)	47 (20%)	4.5 (3.8)	Minor	11%
				Mod	5%
				Severe	4%
Agitation	2.45 (3.76)	109 (45%)	5.4 (3.9)	Minor	19%
				Mod	14%
				Severe	12%
Depression	1.78 (3.22)	102 (43%)	4.2 (3.8)	Minor	25%
				Mod	10%
				Severe	8%
Anxiety	2.16 (3.51)	104 (43%)	5.0 (3.8)	Minor	20%
				Mod	13%
				Severe	10%
Elation	0.49 (1.61)	35 (15%)	3.3 (2.9)	Minor	10%
				Mod	4%
				Severe	1%
Apathy	1.82 (3.59)	73 (30%)	6.0 (4.2)	Minor	10%
				Mod	10%
				Severe	10%
Disinhibition	1.26 (2.86)	66 (28%)	4.6 (3.8)	Minor	15%
				Mod	7%
				Severe	6%
Irritability	2.34 (3.60)	111 (46%)	5.1 (3.8)	Minor	21%
				Mod	15%
				Severe	10%
Motor disturbance	1.81 (3.61)	69 (29%)	6.3 (4.1)	Minor	10%
				Mod	8%
				Severe	11%
Night time	1.58 (3.20)	75 (32%)	5.1 (3.9)	Minor	14%
				Mod	11%
				Severe	7%
Appetite	0.46 (1.63)	34 (14%)	3.3 (3.1)	Minor	10%
				Mod	3%
				Severe	11%
Total score	17.93 (18.20)	6%)			

*Scores = Minor = 1-3, Moderate = 4-8, Severe = 9+.

3.3.2.8 Neuropsychological measures

3.3.2.8.1 Mini mental state examination

The mean MMSE score was 13.5 (SD 7.1) with scores ranging throughout the scale from 0-30. Five residents had a score of 0 and only one scored the maximum score of 30. Ninety

percent of participants scored <24, the definition of cognitive impairment and 97% scored <27, the cut point for mild cognitive impairment. The results of this test had a normal distribution with a skew score of 0.26 (SE 0.16).

3.3.2.9 Falls follow up

Those who were followed up for ≥4 months or fell before loss to follow up were included in this analysis. Of these, the mean length of follow up was 5.5 months (SD 0.9) ranging from 1 to 8 months. Reasons for loss to follow up included death n=13 (5%), admission to hospital n=10 (4%) and transfer to another care home n=2 (1%).

One hundred and twenty one participants (50.4%) fell one or more times during the follow up period. Sixty (25%) of the participants fell 2 or more times (multiple fallers).

Of the fallers, the number of falls ranged between 1 and 16 per person. The mean number of falls in this group was 2.3 (SD 2.2). The total number of falls sustained was 281.

The falls rate was 2.8 (SD 5.3) falls per person per year.

Table 3.9 Circumstances of falls

	N (%)
Falls indoors	
Standing, walking, turning	83 (30)
Getting on/off the bed, chair or toilet	158 (56)
Stairs	1 (0.2)
Other	19 (7)
Falls in the garden	
On the path	1 (0.2)
Stairs	1 (0.2)
Falls outside the home	
In the street	1 (0.2)
In a public building	1 (0.2)
Not known / recorded	16 (6)
Total	281(100)

The vast majority of falls occurred indoors and half (56%) occurred while getting on/off a chair, bed or toilet. Most of the other falls (30%) occurred while standing, walking or turning. In terms of location, half of all falls occurred in the residents' own rooms (56%) with a further 19% falling in communal rooms (Table 3.9 and Table 3.10). The majority of falls (39%) were unwitnessed and the resident was not able to provide a reason why they fell (i.e. they were found on the floor). Other reasons given for falls included losing balance (19%), tripping (8%) and slipping (7%). In addition to this, 10% of falls were so called "unexplained" in as much as the resident found themselves on the floor without explanation (Table 3.11).

Table 3.10 Location of falls

Location	**N (%)**
Bedroom (own)	156 (56)
Day room	52 (19)
Bathroom (own)	23 (8)
Corridor	21 (7)
Bathroom (other)	5 (2)
Bedroom (other)	2 (0.8)
Stairs	1 (0.2)
Other	4 (1)
Not known / recorded	17 (6)
Total	281 (100)

Table 3.11 Reasons for falling

Reason	**N (%)**
Trip	22 (8)
Slip	19 (7)
Felt giddy/faint	3 (1)
Lost balance	55 (19)
Legs gave way	16 (6)
Not sure, suddenly on the floor	28 (10)
Found on the floor, no explanation	110 (39)
Other	17 (6)
Not known/recorded	11 (4)
Total	281 (100)

Most residents could not get up independently following the fall with 41% requiring assistance from carers and another 41% needing hoisting (Table 3.12).

Table 3.12 How did they get up?

Method	N (%)
Got up independently	18 (6)
Hoist required	115 (42)
Physical help from carer required	116 (41)
Other	19 (7)
Not known/recorded	13 (5)
Total	281 (100)

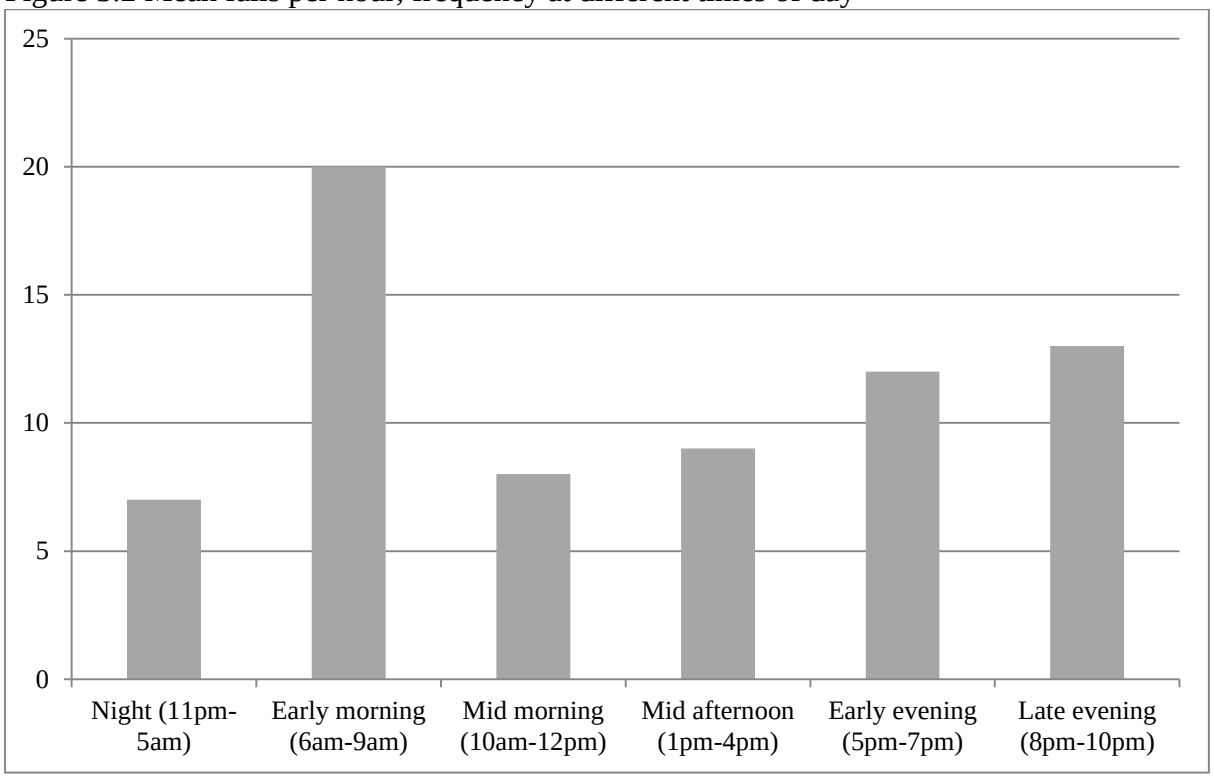
Of the fallers, 60 (50%) sustained an injury with 7 (6%) sustaining a fracture and 56 (46%) minor injuries (cuts, bruises, sprains and pain) (Table 3.13). One hundred and thirteen fall events (39%) required some sort of healthcare intervention. Most falls related injuries only required treatment by care home staff (19%) but 10% required a GP visit, 7% attendance at the emergency department and 3% a hospital admission (Table 3.13).

Table 3.13 Types of injuries and healthcare use for all participants

Injuries sustained	N (%)	Healthcare required	N (%)
No injury	188 (67)	No healthcare needed	138 (49)
Cuts	44 (16)	Care home staff provided care	54 (19)
Bruises	30 (11)	GP visit	29 (10)
Sprain	2 (1)	Emergency department visit	21 (7)
Pain	6 (2)	Hospital admission	9 (3)
Dislocation	0 (0)	Not known / recorded	30 (11)
Fracture	7 (2)		
Not known / recorded	4 (1)		
Total	281 (100)	Total	281 (100)

Falls occurred at all times during the day. The highest mean frequency of falls was between 6 and 7am when a mean of 22 falls occurred and then between 8 and 9am, 6 and 7pm and 9 and 10pm when 17 falls occurred in each of these time slots. When the day was broken down into different periods, the early morning saw the highest frequency of falls with 20 falls per hour, whereas the lowest frequency was during the night with 7 falls per hour (Figure 3.2).

Figure 3.2 Mean falls per hour, frequency at different times of day



3.3.3 Relationships between the baseline variables

Table 3.14 shows the significant correlations between the baseline variables used in this study. The highest r was 0.73 which indicates no problem with collinearity in this sample. There were significant relationships between function (Barthel), sit to stand and balance function. Also the greater the extent of cognitive impairment, the more likely the resident was to exhibit dementia related behaviours (NPI) and be impulsive. Number of medical conditions and number of medications taken were also closely related.

Table 3.14 Correlations between variables

Variable	Correlated variable	R	P value
Age	MMSE	-0.22	0.016
	No of medical conditions	-0.19	0.039
Urinary incontinence	Barthel	-0.63	<0.001
	Sit to stand score	-0.41	<0.001
	Standing balance score	-0.32	<0.001
	NPI	0.27	0.002
	MMSE	-0.38	<0.001

Variable	Correlated variable	R	P value
Barthel	Urinary incontinence	-0.63	<0.001
	Sit to stand score	0.70	<0.001
	Standing balance	0.61	<0.001
	NPI	-0.24	0.009
	MMSE	0.29	0.001
No. of medical conditions	Number of medications	0.41	<0.001
Sit to stand score	Urinary incontinence	-0.41	<0.001
	Barthel	0.71	<0.001
	Standing balance	0.73	<0.001
Standing balance	Urinary incontinence	-0.32	<0.001
	Barthel	0.61	<0.001
	Sit to stand score	0.73	<0.001
	Impulsivity	0.24	0.008
No. of medications	No of medical conditions	0.41	<0.001
NPI	Urinary incontinence	0.27	0.002
	Barthel	-0.24	0.009
	MMSE	-0.44	<0.001
	Impulsivity	0.54	<0.001
MMSE	Age	-0.22	0.016
	Urinary incontinence	-0.38	<0.001
	Barthel	0.29	0.001
	NPI	-0.44	<0.001
	Impulsivity	-0.41	<0.001
Impulsivity	Standing balance	0.24	0.008
	NPI	0.45	<0.001
	MMSE	-0.41	<0.001

3.3.4 Relationships between baseline variables and faller status

3.3.4.1 Univariate analysis

3.3.4.1.1 Continuous variables

Fallers vs non fallers

Fallers took more medications, exhibited more dementia related behaviours (NPI) and were more impulsive (Table 3.15). There was no age difference between fallers and non-fallers (a mean age of 84.2 ±8.25 for fallers and 83.2 ±8.89 for non-fallers (t=-0.92, df=238, p=0.36)).

Table 3.15 Differences in continuous variables between fallers and non-fallers and multiple and non-multiple fallers

	Non-fallers Mean (SD) N=119	**Any (≥ 1) faller Mean (SD) N=121**	**Multiple (≥2)fallers Mean (SD) N=60**
Number of risk related medical conditions[1]	1.4 (1.1)	1.8 (1.2)	1.9 (1.28)
Number of medications	6.7 (3.5)	8.0 (3.4)*	8.5 (3.30)**
Barthel	62.1 (26.3)	52.5 (25.0)	51.4 (22.8)
Care staff balance question†	4.49 (1.46)	4.04 (1.39)	4.05 (1.11)
Care staff sit to stand question†	2.81 (0.63)	2.67 (0.68)	2.70 (0.62)
Impulsivity and wandering index‡	4.66 (2.85)	5.89 (3.74)*	6.25 (4.53)
NPI‡	14.43 (17.3)	21.37 (18.52)*	21.47 (19.55)
MMSE	14.7 (7.5)	12.4 (6.5)	13.04 (6.50)

† Analysis used the Mann-Whitney test as data ordinal

‡ Analysis used the Mann-Whitney test as data skewed which was not improved by log transformation

[1] = Conditions summed if present = stroke, hypertension, diabetes, arthritis, Parkinson's disease, previous hip fracture and depression

* Significant difference between fallers and non-fallers when adjusting for 8 tests using Bonferroni's adjustment ($p<0.006$).

** Significant difference between multiple and non-multiple fallers when adjusting for 8 tests using Bonferroni's adjustment ($p<0.006$).

Table 3.16 Breakdown of Barthel Scores

Barthel	**N-faller Mean(SD) =119**	**Faller Mean(SD) =121**	**P value**
Feeding (0-10)	9.3 (2.2)	8.6 (2.8)	0.028
Bathing (0-5)	0.9 (1.9)	0.6 (1.7)	0.24
Dressing (0-10)	4.8 (4.6)	3.1 (4.1)	0.004
Grooming (0-5)	1.7 (2.3)	0.9 (1.9)	0.008
Bladder function (0-10)	6.1 (4.3)	4.9 (4.5)	0.04
Bowel function (0-10)	7.4 (4.0)	6.1 (4.4)	0.019
Toilet (0-10)	7.3 (4.0)	5.4 (4.6)	0.001
Transfers (0-15)	12.9 (4.3)	12.2 (4.4)	0.22
Mobility (0-15)	11.4 (6.1)	10.6 (6.1)	0.27
Stairs (0-10)	0.5 (2.1)	0.2 (1.3)	0.18

The individual scores of the Barthel, NPI and impulsivity questionnaire were compared to determine which domains were different between fallers and non-fallers. Fallers had worse Barthel scores for feeding, dressing, grooming, bowel, bladder and toileting. The measures of transfers, mobility and stairs were not significantly different.

Table 3.17 Breakdown of impulsivity scores

	N-faller N (%) =119	**Faller N (%) =121**	**RR**
Impulsive	23 (19)	37 (31)	1.39 (0.98-1.97)
	N-faller Mean (SD) =119	**Faller Mean(SD) =121**	**P value (Mann-Whitney)**
Trying to sit down	1.3 (0.8)	1.7 (1.3)	0.007
Attempting to stand	1.3 (0.8)	1.5 (1.0)	0.004
Trying to walk without help	1.3 (0.9)	1.5 (1.1)	0.016
Wandering score	0.6 (1.2)	0.9 (1.5)	0.13

On the impulsivity questionnaire fallers were significantly more likely to be impulsive in the 3 questions regarding sitting down, standing up and walking without help.

Table 3.18 Breakdown of NPI scores

NPI	**N-faller Mean(SD) =119**	**Faller Mean(SD) =121**	**P value (Mann-Whitney)**
Delusions	1.1 (2.8)	0.8 (2.2)	0.8
Hallucinations	0.8 (2.3)	1.0 (2.5)	0.6
Agitation	2.1 (3.5)	2.8 (4.0)	0.1
Depression	1.3 (2.7)	2.2 (3.6)	0.08
Anxiety	1.8 (3.3)	2.5 (3.7)	0.1
Elation	0.4 (1.4)	0.6 (1.8)	0.9
Apathy	1.2 (2.8)	2.5 (4.1)	0.03
Disinhibition	1.2 (2.8)	1.3 (3.0)	0.8
Irritability	1.8 (3.2)	2.9 (3.9)	0.02
Motor behaviour	1.5 (3.3)	2.1 (3.9)	0.5
Night time disturbance	1.0 (2.4)	2.1 (3.8)	0.03
Appetite	0.3 (1.4)	0.6 (1.8)	0.03

In the NPI, fallers were more apathetic, irritable and had more night time disturbances and problems with appetite (Table 3.16, Table 3.17 and Table 3.18).

Multiple fallers Vs Non-multiple fallers

The only significant difference between multiple and non-multiple fallers was that multiple fallers took more medications (Table 3.15).

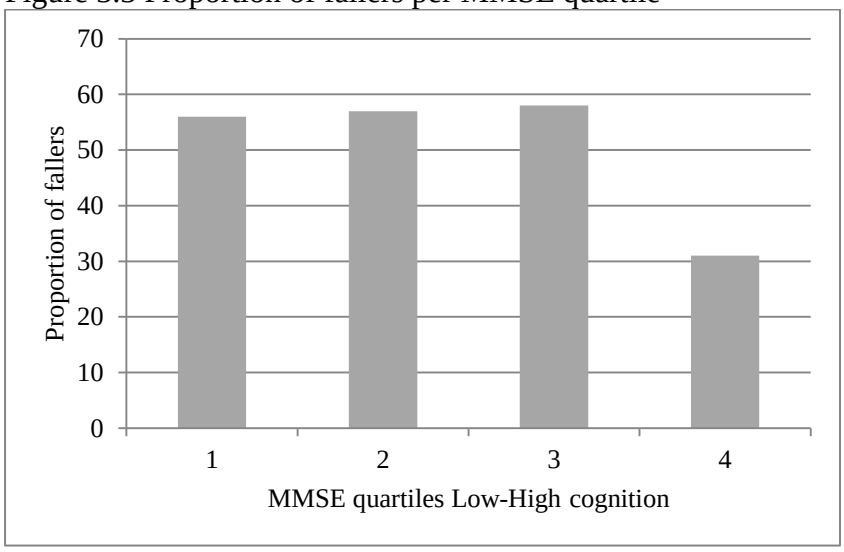
Non-linear patterns

Figure 3.3-Figure 3.7 show the proportion of fallers with scores in each quartile in the MMSE, Barthel, and NPI as well as each score on the sit-to-stand and standing balance categories. Higher NPI scores were associated with linear increases in proportions of fallers. Sit to stand scores were linearly related to falls as those with the best scores had the fewest falls.

The lowest 3 quartiles of the MMSE had very similar proportions of fallers with only the highest quartile (least impaired) having fewer falls. Standing balance scores had similar proportions of faller for each score with the exception of the best score where there were fewer falls.

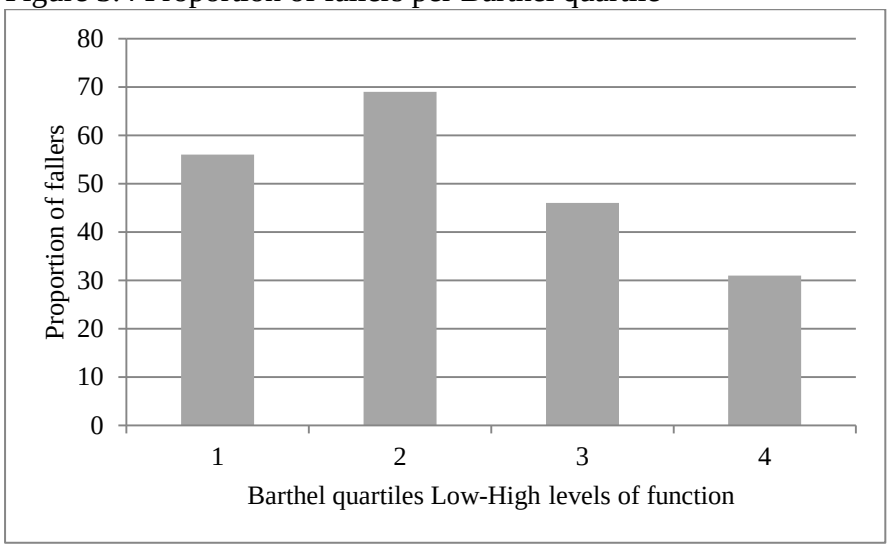
Those in second lowest quartile of the Barthel had the highest proportion of fallers suggestive of a non-linear pattern.

Figure 3.3 Proportion of fallers per MMSE quartile



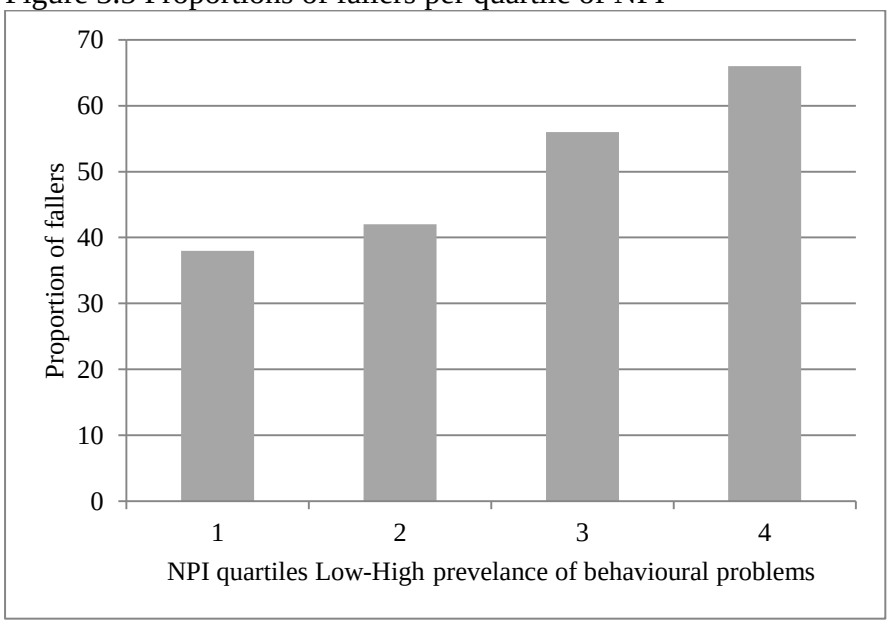
MMSE scores per quartile. 1=0-7, 2=8-12, 3=13-18, 4=19-24

Figure 3.4 Proportion of fallers per Barthel quartile



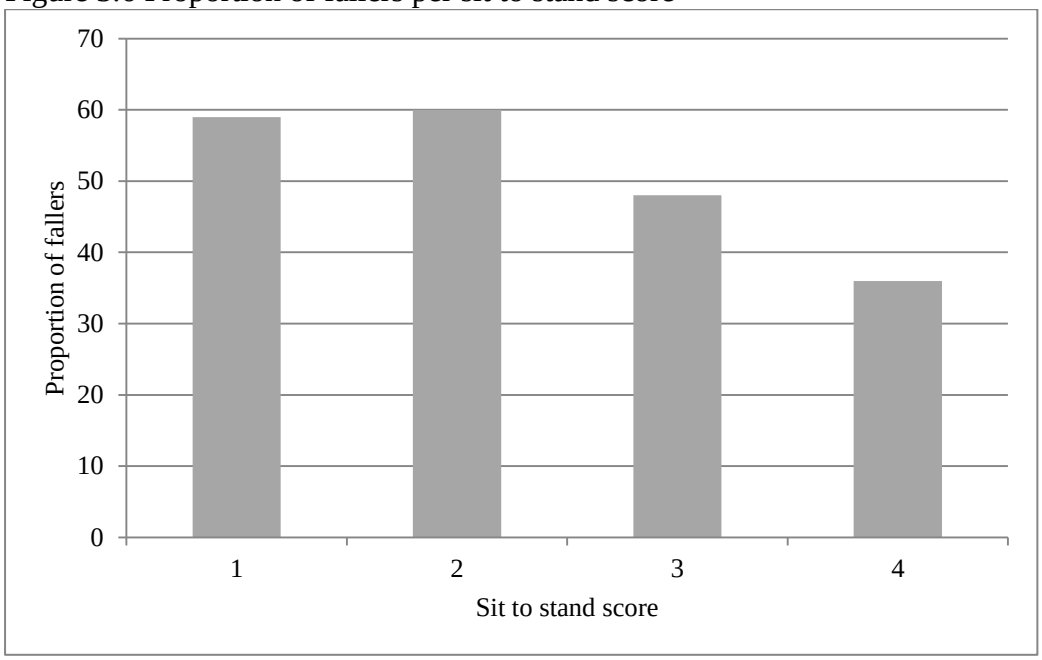
Barthel scores per quartile. 1=0-35, 2=36-65, 3=66-80, 4=81-100

Figure 3.5 Proportions of fallers per quartile of NPI



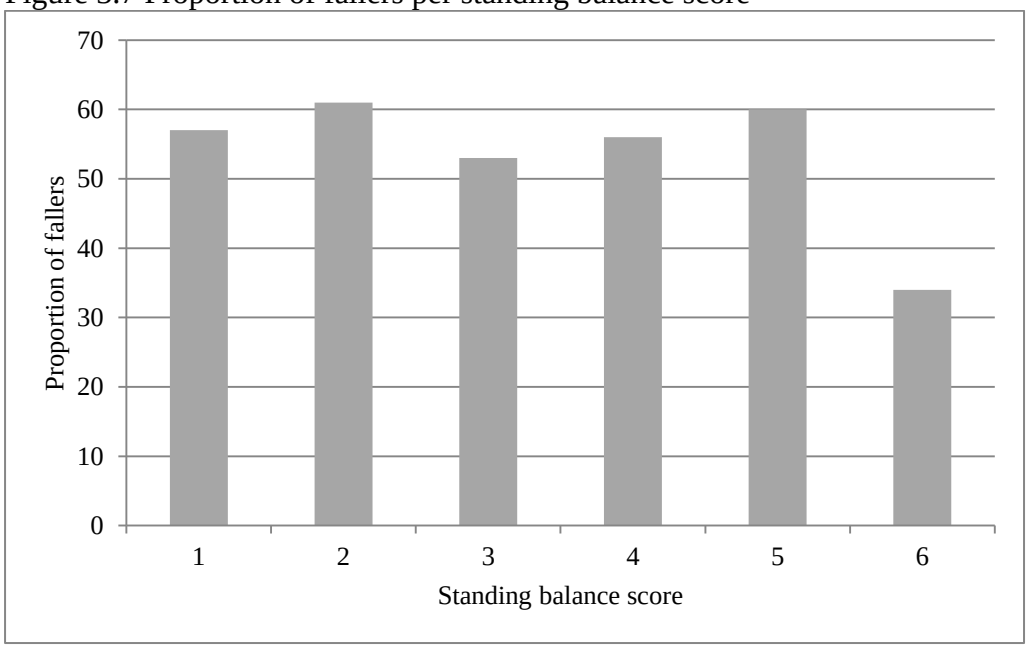
NPI scores per quartile. 1=0-3, 2=4-13, 3=14-26, 4=27-44

Figure 3.6 Proportion of fallers per sit to stand score



Sit to stand scores. 1=unable, 2=requires assistance, 3=needs to use arms, 4=without arms

Figure 3.7 Proportion of fallers per standing balance score



Balance scores. 1=Unable, 2=Assistance of 2, 3=assistance of 1, 4=walking aid, 5=without aid / assistance but unsteady, 6=Stands without aid / assistance steady

3.3.4.1.2 Categorical data

There were no significant differences (Chi square value=8.83 df=9, p=0.45) in the proportion of fallers in each care home with rates ranging from 40-70% (mean 50%). There were also no differences between multiple and non-multiple fallers depending on care home (chi square value=14.2, df=9, P=0.11) with rates ranging from 6-53% (mean 25%).

No significant differences were identified between faller status (all falls or multiple falls) and different diagnoses of cognitive impairment.

3.3.4.1.3 Dichotomous data

When analysing individual medical conditions (examining conditions affecting ≥20% of the sample), no significant differences were found between fallers and non-fallers and non-multiple and multiple fallers in the prevalence of any single medical condition (Table 3.19).

Table 3.19 Medical conditions with a prevalence of ≥20% and their association with falls

Diagnosis	Fallers			Multiple (2+) fallers		
	N-faller N (%) =119	Faller N (%) =121	RR (95%CI)	N-MFaller N (%) =180	M-Faller N (%) =60	RR (95%CI)
Diabetes	24 (20)	32 (26)	1.21 (0.86-1.68)	39 (22)	17 (28)	1.10 (0.90-1.33)
Depression	17 (14)	30 (25)	1.46 (0.98-2.19)	32 (18)	15 (25)	1.13 (0.91-1.39)
Hypertension	44 (37)	53 (44)	1.16 (0.88-1.51)	71 (39)	26 (43)	1.04 (0.90-1.21)
Stroke	22 (19)	32 (26)	1.29 (0.90-1.82)	36 (20)	18 (30)	1.16 (0.95-1.42)
Arthritis	44 (37)	45 (37)	1.01 (0.77-1.31)	64 (36)	25 (42)	1.07 (0.91-1.25)

Examining individual drug groups (taken by ≥10% of the sample), fallers took more antiplatelet drugs, serotonin reuptake inhibitors (SSRIs) and calcium and vitamin D than non-fallers. Multiple fallers took more proton pump inhibitors, stimulant laxatives, antiplatelet drugs and calcium and vitamin D (Table 3.20).

Table 3.20 Medications with a prevalence of ≥10% and their association with falls

Medication	**Fallers**			**Multiple (2+) fallers**		
	N-faller N (%) =119	Faller N (%) =121	RR (95%CI)	N-MFaller N (%) =180	M-Faller N (%) =60	RR (95%CI)
Proton pump inhibitors	37 (31)	46 (38)	1.17 (0.88-1.55)	54 (30)	29 (48)	1.23 (1.04-1.47)
Stimulant laxatives	32 (27)	46 (38)	1.31 (0.97-1.77)	51 (28)	27 (45)	1.22 (1.02-1.47)
Osmotic laxatives	41 (35)	42 (35)	1.01 (0.77-1.32)	57 (32)	26 (43)	1.14 (0.97-1.35)
Thiazides	16 (13)	19 (16)	1.10 (0.75-1.62)	27 (15)	8 (13)	0.97 (0.79-1.18)
Loop diuretics	25 (21)	23(19)	0.94 (0.69-1.28)	35 (19)	13 (22)	1.04 (0.86-1.25)
ACE inhibitors	30 (25)	24 (20)	0.86 (0.65-1.14)	42 (23)	12 (20)	0.95 (0.81-1.13)
Calcium channel blockers	28 (24)	21 (17)	0.83 (0.63-1.11)	35 (19)	14 (23)	1.06 (0.88-1.29)
Anti platelet drugs	51 (43)	68 (56)	1.31 (1.01-1.70)	82 (46)	37 (62)	1.18 (1.01-1.36)
Lipid regulating drugs	40 (34)	46 (38)	1.10 (0.84-1.45)	60 (33)	26 (43)	1.12 (0.98-1.52)
Anti-psychotic drugs	20 (17)	25 (21)	1.14 (0.80-1.63)	35 (19)	10 (17)	0.96 (0.80-1.14)
SSRIs	12 (10)	38 (31)	2.35 (1.41-3.90)	32 (18)	18 (30)	1.22 (0.98-1.52)
Non opioid analgesia	52 (44)	57 (47)	1.07 (0.83-1.39)	77 (43)	32 (53)	1.11 (0.96-1.29)
Control of epilepsy	13 (11)	16 (13)	1.21 (0.73-1.72)	21 (12)	8 (13)	1.04 (0.82-1.32)
Thyroid hormones	14 (12)	15 (12)	1.03 (0.69-1.54)	21 (12)	8 (13)	1.04 (0.82-1.32)
Bisphosponates	16 (13)	29 (24)	1.49 (0.98-2.25)	29 (16)	16 (27)	1.20 (0.96-1.51)
Oral iron	18 (15)	24 (20)	1.19 (0.82-1.73)	26 (14)	16 (27)	1.26 (0.98-1.61)
Drugs for megaloblastic anaemia	11 (9)	17 (14)	1.30 (0.80-2.09)	16 (9)	12 (20)	1.35 (0.97-1.88)
Vitamin B	20 (17)	8 (7)	0.65 (0.50-0.86)	26 (14)	2 (3)	0.78 (0.69-0.89)
Calcium and vitamin d	31 (26)	50 (41)	1.45 (1.06-1.97)	53 (29)	28 (47)	1.22 (1.02-1.46)
Emollients	22 (19)	32 (26)	1.28 (0.90-1.82)	41 (23)	13 (22)	0.98 (0.83-1.17)

When drugs were grouped into larger classes and groups known to increase falls risk examined, fallers took more central nervous system drugs, hypnotics/anxiolytics and any type of antidepressants. Multiple fallers took more gastro-intestinal drugs, anti-hypertensive's, central nervous system drugs (when analgesia was excluded) and hypnotics/anxiolytics (Table 3.21).

Table 3.21 Classes of medications and groups associated with falls

Classes of medications	**Fallers**			**Multiple (2+) fallers**		
	N-faller N (%) =119	Faller N (%) =121	RR (95%CI)	N-MFaller N (%) =180	M-Faller N (%) =60	RR (95%CI)
GI drugs (any)	74 (62)	88 (73)	1.26 (0.98-1.63)	112 (62)	50 (83)	1.26 (1.10-1.44)
Cardiovascular drugs (excl lipid)	70 (59)	73 (60)	1.03 (0.80-1.34)	1.04 (58)	39 (65)	1.08 (0.93-1.25)
Cardiovascular drugs excl lipid and antiplatelet)	30 (25)	26 (22)	0.90 (0.68-1.20)	42 (23)	14 (23)	1.00 (0.84-1.19)
Antihypertensive drugs (any)	50 (42)	49 (41)	0.97 (0.75-1.25)	72 (40)	27 (45)	1.05 (1.05-1.35)
ACE inhibitors and AR blockers	36 (30)	27 (22)	0.82 (0.63-1.07)	50 (28)	13 (22)	0.93 (0.79-1.08)
Respiratory drugs (any)	17 (14)	13 (11)	0.56 (0.61-1.21)	24 (13)	6 (10)	0.93 (0.76-1.13)
CNS drugs (any)	83 (70)	99 (82)	1.36 (1.05-1.76)	132 (73)	50 (83)	1.14 (0.98-1.32)
CNS drugs (excl analgesia)	52 (44)	78 (65)	1.52 (1.18-1.97)	91 (51)	39 (65)	1.16 (1.00-1.34)
Hypnotics/anxiolytics	6 (5)	19 (16)	2.19 (1.08-4.45)	13 (7)	12 (20)	1.49 (1.02-2.19)
Antidpressants	24 (20)	53 (44)	1.87 (1.31-2.67)	52 (29)	25 (42)	1.16 (0.98-1.38)
Non-opioid analgesia and NSAIDS	53 (45)	59 (49)	1.09 (0.84-1.41)	78 (43)	34 (57)	1.14 (0.99-1.33)
Drugs for infection (any)	8 (7)	6 (5)	0.86 (0.54-1.38)	11 (6)	3 (5)	0.95 (0.72-1.26)
Drugs for diabetes (any)	16 (13)	19 (16)	1.10 (0.75-1.62)	24 (13)	11 (18)	1.11 (0.88-1.41)
Drugs for thyroid (any)	15 (13)	16 (13)	1.03 (0.70-1.52)	22 (12)	9 (15)	1.07 (0.84-1.35)
Musculoskeletal drugs (any)	7 (6)	12 (10)	1.38 (0.75-2.51)	11 (6)	8 (13)	1.32 (0.89-1.95)
Drugs for eyes (any)	8 (7)	17 (14)	1.61 (0.90-2.90)	19 (11)	6 (10)	0.99 (0.78-1.24)

Of the remaining dichotomous data, fallers and multiple-fallers were more likely to have fallen in the previous year and use a walking frame than non-fallers or non-multiple fallers. There were no significant differences in sex, ethnicity, nursing care requirements or urinary incontinence (Table 3.22).

Table 3.22 Other dichotomous data

	Fallers			**Multiple (2+) fallers**		
	N-faller N (%) =119	Faller N (%) =121	RR (95%CI)	N-MFaller N (%) =180	M-Faller N (%) =60	RR (95%CI)
Female	72 (61)	82 (68)	1.17 (0.91-1.51)	111 (62)	43 (72)	1.11 (0.96-1.29)
Caucasian	97 (82)	102 (84)	1.10 (0.80-1.51)	148 (82)	51 (85)	1.05 (0.88-1.26)
Fall in the last year	70 (59)	101 (84)	1.74 (1.37-2.19)	119 (66)	52 (87)	1.27 (1.12-1.45)
Requires nursing care	17 (14)	23 (19)	1.20 (0.82-1.76)	30 (17)	10 (17)	1.00 (0.82-1.22)
Frame user	39 (37)	59 (48)	1.39 (1.05-1.85)	63 (35)	34 (57)	1.26 (1.07-1.49)
Wanderer	27 (23)	37 (31)	1.24 (0.90-1.71)	50 (28)	14 (23)	0.95 (0.81-1.11)
Urinary incontinence	59 (50)	72 (60)	1.22 (0.95-1.58)	94 (52)	37 (62)	1.10 (0.95-1.27)

3.3.4.2 Logistic regression

The cut points identified using the Youden index, with sensitivity, specificity and relative risks are provided in Table 3.23.

Table 3.23 Dichotomised continuous data

Dichotomised variable	Cut point	Non-fallers (n=119) N (%)	Fallers (n=121) N (%)	Sensitivity (95%CI)	Specificity (95%CI)	RR (95%CI)
≥2 more medical conditions[1]	Yes	52 (44)	68 (56)	0.56 (0.47-0.65)	0.56 (0.47-0.66)	1.29 (0.99-1.67)
Barthel	<65	42 (35)	72 (60)	0.60 (0.50-0.68)	0.65 (0.55-0.73)	1.66 (1.26-2.19)
NPI	>11	48 (40)	77 (64)	0.64 (0.54-0.72)	0.60 (0.50-0.68)	1.60 (1.23-2.10)
MMSE	<17	66 (56)	92 (76)	0.76 (0.67-0.83)	0.45 (0.36-0.54)	1.55 (1.21-1.98)
Total impulsivity score	>4	35 (29)	65 (54)	0.53 (0.44-0.63)	0.71 (0.61-0.78)	1.71 (1.27-2.31)
Medications	≥6	66 (56)	100 (83)	0.83 (0.74-0.89)	0.45 (0.36-0.54)	1.80 (1.42-2.28)
STS score	<3	23 (19)	34 (28)	0.28 (0.20-0.37)	0.81 (0.72-0.87)	1.30 (0.92-1.84)
Standing balance score	<6	74 (62)	98 (81)	0.81 (0.73-0.87)	0.38 (0.29-0.47)	1.54 (1.21-1.96)

[1] = Conditions summed if present = stroke, hypertension, diabetes, arthritis, Parkinson's disease, previous hip fracture and depression

All dichotomous data listed in Table 3.24 and dichotomised data in Table 3.23 were entered into logistic regression analysis.

Calcium and vitamin D contributed significantly, to the initial model but logistic regression was repeated without it as it was felt to be a confounding variable (fallers are more likely to be prescribed this medication because they are fallers).

Table 3.24 Dichotomous variables with sensitivity, specificity, relative risks to be entered into logistic regression analysis

Measure	Cut point	Non-fallers (n=119) N (%)	Fallers (n=121) N (%)	Sensitivity (95%CI)	Specificity (95%CI)	RR (95%CI)
Fall in last year	Yes	70 (59)	101 (84)	0.83 (0.75-0.89)	0.41 (0.32-0.51)	1.74 (1.37-2.19)
Requires walking frame	Yes	39 (33)	58 (48)	0.48 (0.39-0.57)	0.67 (0.58-0.75)	1.39 (1.05-1.85)
Incontinent of urine	Yes	59 (50)	72 (60)	0.60 (0.50-0.68)	0.50 (0.41-0.60)	1.22 (0.95-1.58)
CNS drugs[2]	Any	56 (47)	81 (67)	0.67 (0.58-0.75)	0.53 (0.44-0.62)	1.50 (1.16-1.93)
Hypnotics/Anxiolytics	Any	6 (5)	19 (16)	0.16 (0.10-0.24)	0.95 (0.89-0.98)	2.19 (1.08-4.45)
Antidepressants	Any	24 (20)	53 (44)	0.44 (0.35-0.53)	0.80 (0.71-0.86)	1.87 (1.31-2.67)
Anti-platelets	Any	51 (43)	68 (56)	0.56 (0.47-0.65)	0.57 (0.48-0.66)	1.31 (1.01-1.70)

[2] = All CNS medications (using BNF classification)

Logistic regression (excluding calcium and vitamin D) identified seven significant and independent predictors of faller status; MMSE <17, OR = 2.17 (95%CI 1.11-4.24); impulsivity score >4, OR = 2.78 (95%CI 1.46-5.31); standing balance score <6, OR = 2.40 (95%CI 1.17-4.96); requiring a walking frame; OR = 2.07 (95%CI 1.06-4.04); falling in the previous year, OR = 3.46 (95%CI 1.77-6.81); taking hypnotic/anxiolytic medication, OR = 3.75 (95%CI 1.25-11.21) and taking antidepressant medication, OR = 2.92 (95%CI 1.51-5.64) (Table 3.25). Cox Snell and Nagelkerke R^2 suggested this model accounted for 26-34% of the variance in faller status and the model correctly predicted 71% of fallers in this sample.

The AUC for the weighted model was 0.79 (95% CI 0.73–0.84) and for the unweighted model 0.78 (95%CI 0.73-0.84). There was no significant difference between these two models χ^2 1.10 P=0.30. The ROC curves for the two models are illustrated in Figure 3.8. The AICs for the weighted and unweighted models were 278 and 268 respectively indicating the unweighted was the slightly better model.

Table 3.25 Details of the logistic regression analysis

Variable	B	Wald	Sig	OR (95%CI)
MMSE	0.77	5.12	0.02	2.17 (1.11-4.24)
Impulsivity	1.02	9.61	0.002	2.78 (1.46-5.31)
Standing balance	0.88	5.63	0.02	2.40 (1.17-4.96)
Frame use	0.73	4.51	0.03	2.07 (1.06-4.04)
Previous falls	1.24	12.94	<0.001	3.46 (1.76-6.81)
Hypnotics /anxiolytics	1.32	5.59	0.02	3.75 (1.25-11.21)
Antidepressants	1.07	10.21	0.001	2.92 (1.51-5.64)

Figure 3.1 Receiver operating curves for the weighted and unweighted models.

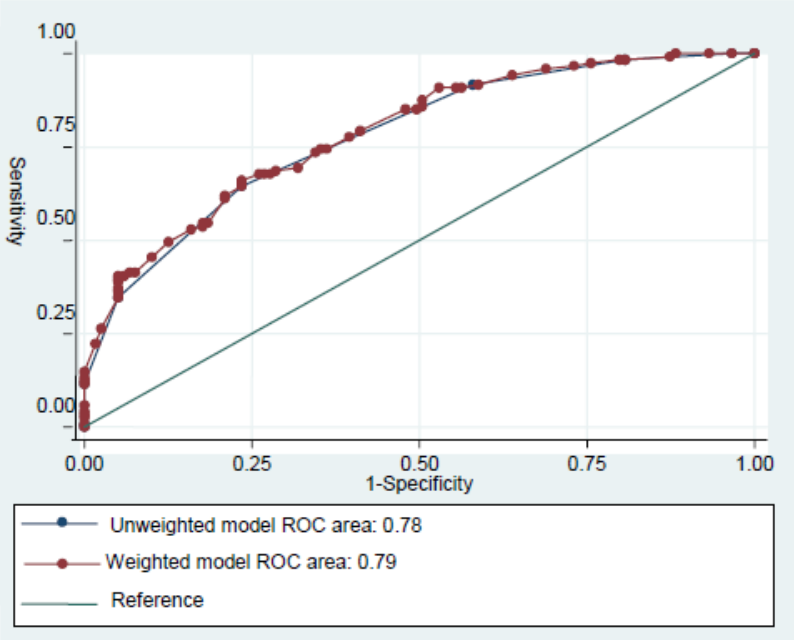
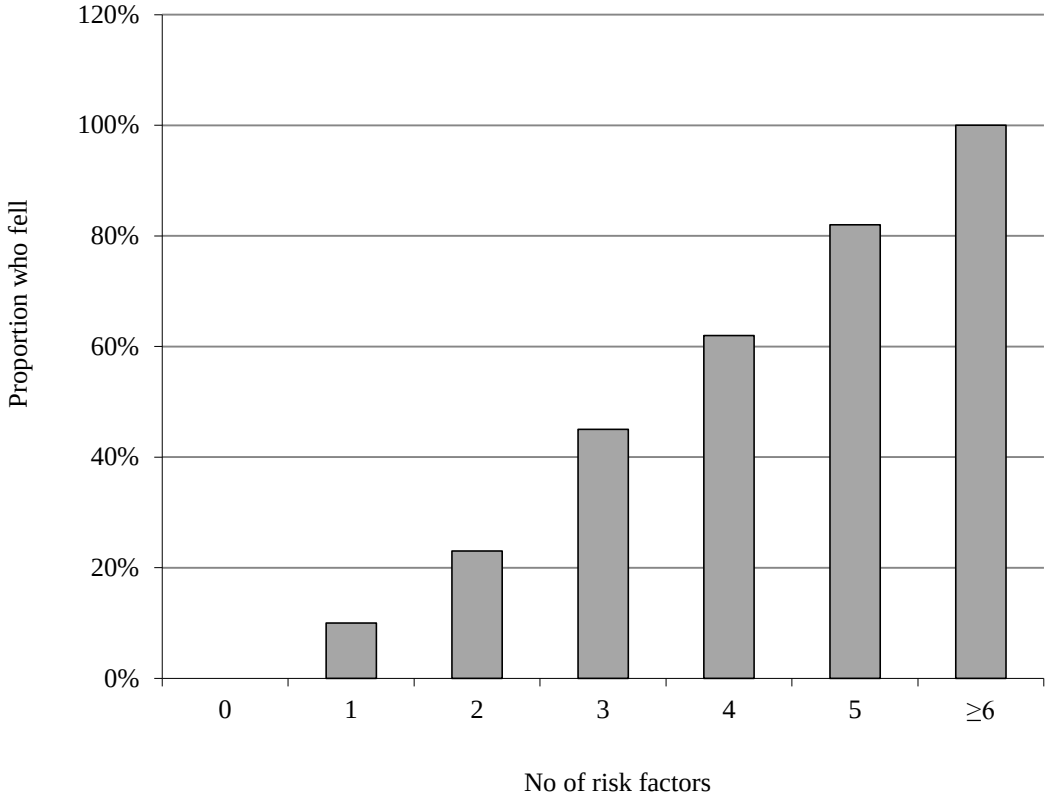


Figure 3.9 presents the proportion of fallers with 0-7 of the risk factors found on logistic regression. None of those with no risk factors fell rising to 100% of those with ≥6 of these risk factors

Figure 3.9 Absolute risk of falls in relation to number of risk factors



Legend: Risk factors identified from the logistic regression analysis: MMSE <17, Impulsivity score >4, standing balance score <6, on axiolytics/hypnotics, on antidepressants, had a fall in the previous year and requires a walking frame.

3.3.5 Relationship between baseline variables and falls rates

3.3.5.1.1 Univariate analysis

Table 3.26 Effect of baseline variables on falls rates (adjusted for months follow up)

Variable	IRR (95%CI)
Fall in the last year	2.81 (1.70-4.63)
Frame user	1.46 (0.97-2.19)
CNS drugs	1.93 (1.29-2.91)
Hypnotics/anxiolytics	1.88 (1.04-3.40)
Antidepressants	1.63 (1.07-2.47)
Antiplatelet drugs	1.73 (1.16-2.58)
Incontinent of urine	1.71 (0.96-2.14)
Barthel <65	1.89 (1.27-2.81)

Variable	IRR (95%CI)
NPI >11	2.15 (1.45-3.20)
Medication ≥6	2.86 (1.80-4.54)
MMSE <17	1.70 (1.11-2.62)
Impulsivity score >4	1.86 (1.25-2.77)
Two or more medical conditions	1.71 (1.15-2.54)
Standing balance score <6	3.05 (1.87-4.96)
STS score <3	1.37 (0.86-2.18)

Falls rates were significantly higher in those who had fallen in the previous year, took CNS, hypnotic/axiolyitc, antidepressant or antiplatelet drugs. Those who had a Barthel score of <65, NPI >11, MMSE <17, standing balance score <6, impulsivity score >4, took ≥6 medications and had 2 or more risk related medical conditions also had significantly higher falls rates (Table 3.26).

3.3.5.1.2 Multivariate analysis

When all the variables in Table 3.26 were entered into negative binomial regression together, only having a fall in the previous year, NPI >11 and standing balance <6 remained significant.

Figure 3.10 Absolute risk of falls using independent risk factors identified using fall rate data

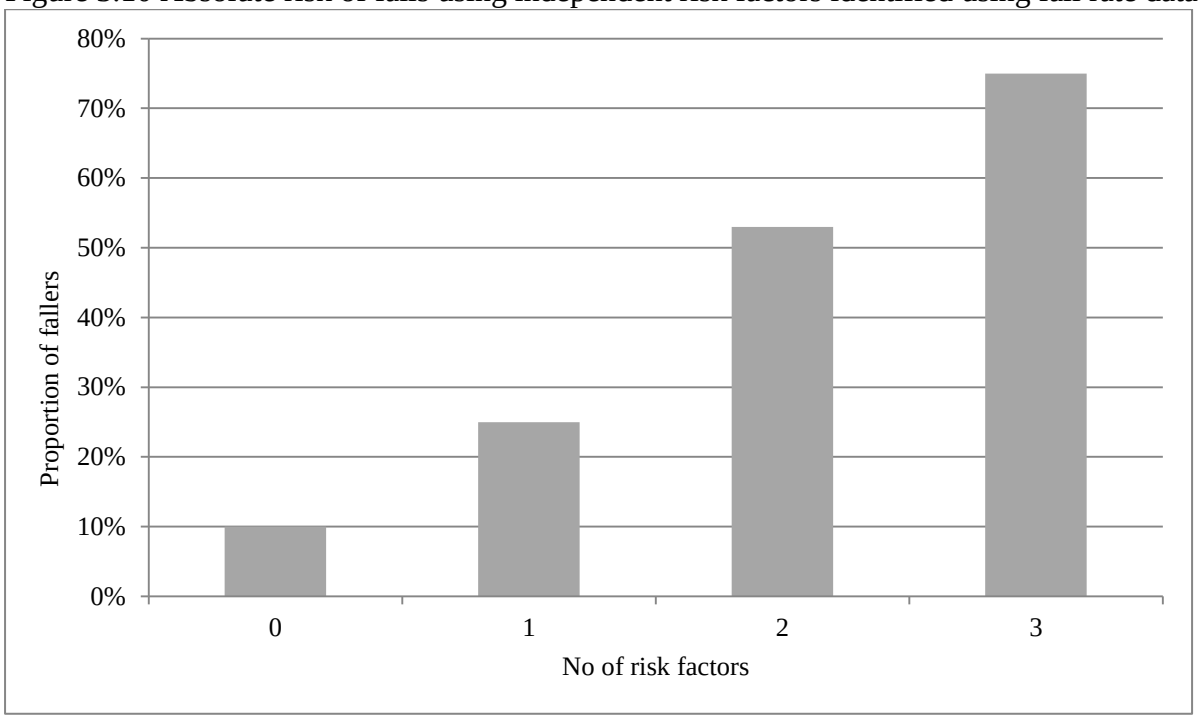


Figure 3.10 illustrates the absolute risk of falls using the risk factors identified on multivariate analysis of factors associated with falls rates using risk factors of a fall in the previous year, NPI>11 and standing balance <6. The weighted AUC for this model was 0.72 (95%CI 0.66-0.78).

3.3.6 Discussion

This study found that impaired cognition, impulsive behaviour, poor standing balance, requiring a walking frame to mobilise, falling in the previous year and antidepressant and hypnotic/anxiolytic use all significantly and independently increased the risk of being a faller in residential care dwellers. The model, using dichotomous and dichotomised data and analysed using logistic regression analysis with faller status (≥1 fall) as the dependent variable had excellent discrimination with respect to quantifying the probability with which a care home resident would fall over a six-month period. Absolute risk of falling ranged from zero in those with no risk factors to 100% in those with six or more risk factors. The results support findings from previous studies suggesting fall risk is multi-factorial in nature and provide cut-points to be used in a fall risk screen based on measures routinely undertaken in the care home setting. However, although this study was undertaken in seven care facilities, external validation is necessary in other care homes.

As in previous work (van Doorn et al., 2003, Thapa et al., 1995, Luukinen et al., 1995c), there was an increase in falls risk for those with poor standing balance, however contrary to some of these studies no non-linear relationships between mobility levels and falls were evident (see Figure 3.6 and Figure 3.7). Barthel scores did appear follow this type of non-linear pattern, but differences between fallers and non-fallers were not related to the mobility components of these scores. It is likely that as most residents had impaired balance, these measures had less discriminatory ability in this setting. In contrast, a study in Australia found non-linear patterns between mobility and falls. This study included not only nursing home residents, but also hostel residents (a form of residential home with low levels of care) who

were more mobile and thus had a higher exposure to fall risk situations (Lord et al., 2003a). In that study, those with best and worst mobility suffered the least falls.

In addition to poor standing balance, requiring a walking frame to mobilise was also identified as an independent and significant predictor of faller status. The inclusion of this measure in the model suggests that frame use is not just a proxy measure of poor balance and that additional factors relating to frame use increase the risk of falls. Having fallen in the previous year has consistently been found to be a strong marker of prospective falls and this result has been replicated here.

This study adds a new dimension in measuring mobility behaviour by using the summed score of impulsivity and wandering questions. This measure almost certainly reflects an important and complex interaction between cognitive and physical function. As this novel measure was included in the final logistic regression model, it appears that this item assists significantly in explaining fall risk.

The data confirms that use of hypnotic/anxiolytic and antidepressant medications increases the risk of falls. It is possible that the conditions requiring prescription of these medications could predispose residents to falls, as residents prescribed these medications had significantly higher NPI scores (mean score taking hypnotics/anxiolytics 25.4±22.9 compared to mean score non using hypnotics/anxiolytics 17.1±17.4 t=2.2, ^{df}238, p=0.001). However, use of both medications remained significant in the final model, suggesting it adds to fall risk over and above the presence of impulsivity and cognitive impairment. Use of anti-platelet agents as a risk factor for falls was unexpected and may possibly reflect vascular burden including small and large vessel disease.

The risk factors identified as significant independent predictors of faller status have been used to form a simple fall risk screening tool to be used in all residential care dwellers (Figure 3.11). The comparison of the weighted and unweighted models indicated the unweighted model (the simple count of risk factors present) lost no discriminatory power for identifying fallers, and thus provides a practical evidence-based screen for clinical settings.

In addition to identifying absolute risk of falls, the screening tool outlines risk factors requiring targeted interventions. This may assist in optimising fall prevention strategies, as to date many intervention trials have not been effective in this population (Kerse et al., 2004, Kerse et al., 2008b, Rubenstein et al., 1990) and those that were used methods which involved identification of risk factors and targeted interventions through comprehensive assessment (Becker et al., 2003). Potential interventions will be discussed in chapter 8.

3.4 Conclusions

Risk factors for being a faller were identified and used to form a simple and quick screen comprising measures of behaviour, cognition, balance and medication use that can quantify the probability with which residential care facility residents will fall over a six-month period.

Figure 3.11 Care Home Falls Risk Screening (CaHFRiS) tool

CaHFRiS - CARE HOME FALLS SCREEN	**Room Number:**
	Surname:
	Date of Birth:

	(Score – Please Circle)	(Tick if applicable)
MMSE (See MMSE performed by healthcare professional)		SCORE 16 or LESS ☐
IMPULSIVITY 1. Does the resident tend to be impulsive when moving around? Impulsive means "rushing to carry out an activity without thinking about it first"?	Yes = 1 No = 0	SCORE 2 OR MORE ☐
2. How often does the resident do the following? Try to sit down before getting right up to the chair / toilet / bed	Very frequently = 4, Frequently = 3, Often = 2, Occasionally = 1, Never = 0	
Attempt to stand before wheelchair brakes have been applied / footplates moved or walking frame placed in front of them	Very frequently = 4, Frequently = 3, Often = 2, Occasionally = 1, Never = 0	
Tries to walk without help when asked not to	Very frequently = 4, Frequently = 3, Often = 2, Occasionally = 1, Never = 0	
3. a. Wandering frequency in last week: b. Wandering alterability (Wandering is defined as moving with no rational purpose, seemingly oblivious to needs or safety)	Every day = 3, 4-6 days =2, 1-3 days = 1, not at all = 0 Easily altered/not present = 0, not easily altered = 1	
STANDING BALANCE Pleas e rate the resident's standing balance using the scale	Unable to stand = 1, Requires assistance of 2 to remain standing = 2, Requires assistance of 1 to remain standing = 3, Requires use of walking aid to remain standing = 4, Stands without aid / assistance but unsteady = 5, Stands without aid / assistance steady = 6.	SCORE 5 OR LESS ☐
WALKING FRAME	Does the resident require a walking frame to mobilise?	YES ☐
FALL IN THE PREVIOUS YEAR	Has the resident had a fall in the last year?	YES ☐
USE OF ANTIDEPRESSANT MEDICATION?	Commonly prescribed antidepressants = *Amitriptyline, Dosulepin, Doxepin, Citalopram, Fluoxetine, Paroxetine, Sertraline, Mirtazapine.* If not sure ask GP for confirmation of any anti depressant prescription	1 OR MORE ☐
USE OF HYPNOTIC/ANXIOLYTIC MEDICATION	Commonly prescribed hypnotics/anxiolytics = benzodiazepines such as diazepam, nitrazepam, temazepam as well as Zaleplon, Zopiclone, Zolpidem. If not sure ask GP for confirmation of any hypnotic/anxiolytic prescription	1 OR MORE ☐

TOTAL NUMBER OF RISK FACTORS (circle below)							
ABSOULTE RISK OF FALLS IN NEXT 6 MONTHS	**0**	**1**	**2**	**3**	**4**	**5**	**6+**
	0%	**10%**	**23%**	**45%**	**62%**	**82%**	**100%**

Defining Falls Risk Factors in Older Adults with Cognitive Impairment Living in Residential Care

Chapter 4

A detailed study to identify risk of falls in people with cognitive impairment living in residential care

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4 A detailed study to identify risk of falls in people with cognitive impairment living in residential care

4.1 Introduction

Cognitive impairment and dementia are common in older age and are associated with many adverse outcomes including falls and fractures (Aguero-Torres et al., 2001, Tinetti and Williams, 1997). Compared with cognitively intact age-matched peers, older people with cognitive impairment have double the annual falls incidence (60%) (van Dijk et al., 1993) and those with dementia have a threefold higher risk of hip fracture (Baker et al., 2011). Despite being a common problem in residential care, there is limited and inconsistent evidence on how to prevent falls in this setting (Cameron et al., 2010).

The increased risk of falls in this population may relate directly to the effects of cognitive dysfunction, and/or a higher prevalence of the non-cognitive risk factors found in the general population of older people. Fall risk increases with reduced performance in the mini mental state examination (Gleason et al., 2009) and specific cognitive deficits including impaired visuospatial function, psychomotor speed, executive function and attention (Eriksson et al., 2007, Olsson et al., 2005, Holtzer et al., 2007). Wandering and agitation, which are common dementia-related behaviours, have also been shown to increase fall risk (van Doorn et al., 2003, Buchner and Larson, 1987).

In terms of general fall risk factors, it has been reported that older people with cognitive impairment have slower walking speed, shorter stride length, poorer obstacle clearance, impaired coordination and balance, reduced balance control when performing a secondary

task, and a greater likelihood of developing mobility problems (Tanaka et al., 1995, Franssen et al., 1999, Buchner and Larson, 1987, Buchman et al., 2011, Alexander et al., 1995). The neurodegenerative process associated with dementia may also increase the risk of falls by increasing the likelihood of autonomic dysfunction including symptomatic orthostatic hypotension (Allan et al., 2005, Passant et al., 1997). Finally, fall risk may be increased by the use of psychotropic medications, particularly sedative hypnotics, antipsychotics and antidepressants (Sterke et al., 2008, Hartikainen et al., 2007), which are more commonly prescribed to people with dementia (Thapa et al., 1995).

Risk factor studies to date have largely focused on discrete areas of either cognitive or physical performance rather than comprehensively examining the diverse physiological, medical and psychological factors for falls in people with cognitive impairment residing in residential care - a setting where it is estimated that at least 50% suffer from dementia (Matthews et al., 2002). Given the increasing prevalence of cognitive impairment and dementia due to population ageing, it is important to have a clear understanding of the relative contribution of a complete range of risk factors so as to more effectively target interventions.

To address this issue, a prospective comprehensive examination of fall risk factors in residential care dwellers with cognitive impairment was undertaken. The primary aim was to develop an explanatory model for falls with the ultimate objective of providing a solid foundation for the design, implementation and evaluation of targeted intervention programs to prevent falls in this population.

4.2 Methods

4.2.1.1 Participants

Ten care homes in South London were invited to participate in the study and of these seven agreed to do so. Residents from these 7 homes were recruited if they scored <82 on the Addenbrooke's Cognitive Examination (ACE-R) as evidence of cognitive impairment as well as the other inclusion / exclusion criteria detailed in chapter 2. Participants who were unable to engage in conversation or were too agitated or restless to participate in the assessment process were deemed ineligible if these signs were apparent on two separate occasions.

Figure 4.1 shows flow of participant recruitment. Informed consent for participation in the study was obtained from the participants and/or from legal carers. The South London and Maudsley Institute of Psychiatry joint ethics committee approved the study.

4.2.1.2 Risk factor data collection

Detailed descriptions of measures are provided in chapter 2.

4.2.1.2.1 Demographic, medical history, medication use and environmental measures

Demographic information and medical history were extracted from the medical and care records. Functional status was measured using the Barthel index (Mahoney and Barthel, 1965). Medication use was determined from prescription chart review. An environmental checklist was completed for each resident (Queensland Government, 2003). Supine and standing blood pressures were measured following the European Society of Cardiology syncope guidelines (Lahrmann et al., 2006).

4.2.1.2.2 Sensorimotor, gait and balance

Functional ability was measured by rating and timing sit to stand function (Guralnik et al., 1994). Gait was measured using the 6m walk (Tiedemann et al., 2008b) and timed up and go test (Podsialdo and Richardson, 1991). Vision measured with the Melbourne edge test, lower limb proprioception, knee extension strength and postural sway combined with hand reaction times were used to calculate the physiological profile assessment falls risk score (Lord et al., 2003b). Additional tests included hand grip strength (Campbell et al., 1989) and standing balance (Guralnik et al., 1994).

4.2.1.2.3 Behavioural and psychiatric symptoms

Depressive symptoms and anxiety were assessed with the geriatric depression scale-15 (GDS) (Yesavage, 1988) and Goldberg anxiety scale (GAS) (Goldberg et al., 1988) respectively. Abnormal behaviour was measured using the neuro-psychiatric inventory (NPI) (Cummings et al., 1994). Wandering was measured by asking carers about the frequency of wandering as used in the Minimum Data Set Version 2. Carers were asked questions about impulsivity using the questionnaire described in chapters 2 and 6.

4.2.1.2.4 Neuropsychological function

The Addenbrooke's cognitive examination revised version (ACE-R) (Mioshi et al., 2006) was used to assess the domains of attention and orientation, memory, fluency, language and visuospatial abilities. Additional cognitive tests included the Boston naming test to assess language (Mack et al., 1992), the WMS-III logical memory story (Wechsler, 1997) to assess immediate and short-term memory, the trail making test A to measure executive function (Bowie and Harvey, 2006) and a test of hand reaction time (Lord et al., 2003b) to assess

processing speed. The “stops walking when talking” test was administered to assess dual task performance (Lundin-Olsson et al., 1997).

4.2.1.3 Falls surveillance

Falls data were collected as described in chapter 2.

4.2.2 Data analysis

Chapter 2 provides information on how skewed data was normalised and missing data was dealt with.

4.2.2.1 Power calculation

Based on previous studies it was estimated that approximately half the sample would fall during the follow-up period. A sample size of 100 was therefore chosen to allow for a minimum of 10 outcome cases (fallers) for up to 5 variables entered into multivariate models (Concato et al., 1993) and be adequate for determining significant differences between faller and non-faller groups.

4.2.2.2 Analysis of faller status

4.2.2.2.1 Univariate analysis

Descriptive data was presented and analysed for relationships using correlation coefficients. Differences between fallers and non-fallers were analysed using t-tests and Mann-Whitney tests (as indicated by the data) for continuous data. Scales with multiple components were broken down and each section compared using the same methods. Categorical data was analysed for differences in faller status using Chi square tests and dichotomous data analysed using Chi square and relative risks.

4.2.2.2.2 Non-linear relationships

Graphs were used to identify non-linear relationships between score quartiles and faller status.

4.2.2.2.3 Multivariate analysis

Forward binary logistic regression analysis (FBLRA) was then used to find the best set of significant and independent predictors of being a faller. In the first instance, all continuous and dichotomous data was entered into FBLRA within their own variable domain ((1) demographic and medical, (2) sensorimotor, balance and gait, (3) behaviour and psychiatric symptoms and (4) neuropsychological). Significant and independent variables identified from each domain were then entered into a single FBLRA (model A).

Continuous variables identified as significant and independent predictors, were dichotomised by calculating the optimal specificity and sensitivity for falls using the Youden index (Ruopp et al., 2008) and FBLRA run again using dichotomised / dichotomous data (model B). This was to allow simple interpretation of the odds ratios in a clinical situation. Discrimination (the ability of a model to distinguish high-risk residents from low-risk residents) was quantified using the area under the receiver-operating characteristic curve (AUC) (Harrell et al., 1996) for models A and B.

4.2.2.3 Univariate and multivariate analysis of falls rates

The relationships between baseline variables and falls rates were analysed using univariate and multivariate incident rate ratios calculated using negative binomial regression analysis and adjusting for follow up time.

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4.3 Results

4.3.1.1 Recruitment

A total of 331 participants were approached to take part in the study. Of these 64 were excluded. Reasons for exclusion are included in Table 4.1.

Table 4.1 Reasons for exclusion

Reasons for exclusion from the study
Bedbound N=5
Aged <60 N=3
Recent hospital admission N=1
Temporary resident N=1
Incapable of assessment N=54

Fifty four of those excluded were deemed not capable of participating in this study due to the extent that their cognitive impairment affected their ability to follow instructions and therefore complete the necessary baseline measurements. This was the case if a person was unable to engage with the researcher or had severely disruptive behaviour on two different occasions (at different times of day). Of the remaining 267, 151 participants or their consultee's refused (74 refused completely, 77 refused detailed assessment but agreed to the screening study). The remaining 116 underwent baseline assessment. Since this was a study to examine falls risk factors in those with cognitive impairment, 6 were excluded as they had an ACE-R score of >82. One participant had <4 months follow up without having had a fall prior to loss from follow up. Therefore the final number included in analysis was 109. See Figure 4.1 for the recruitment flow.

Figure 4.1 Recruitment into the study

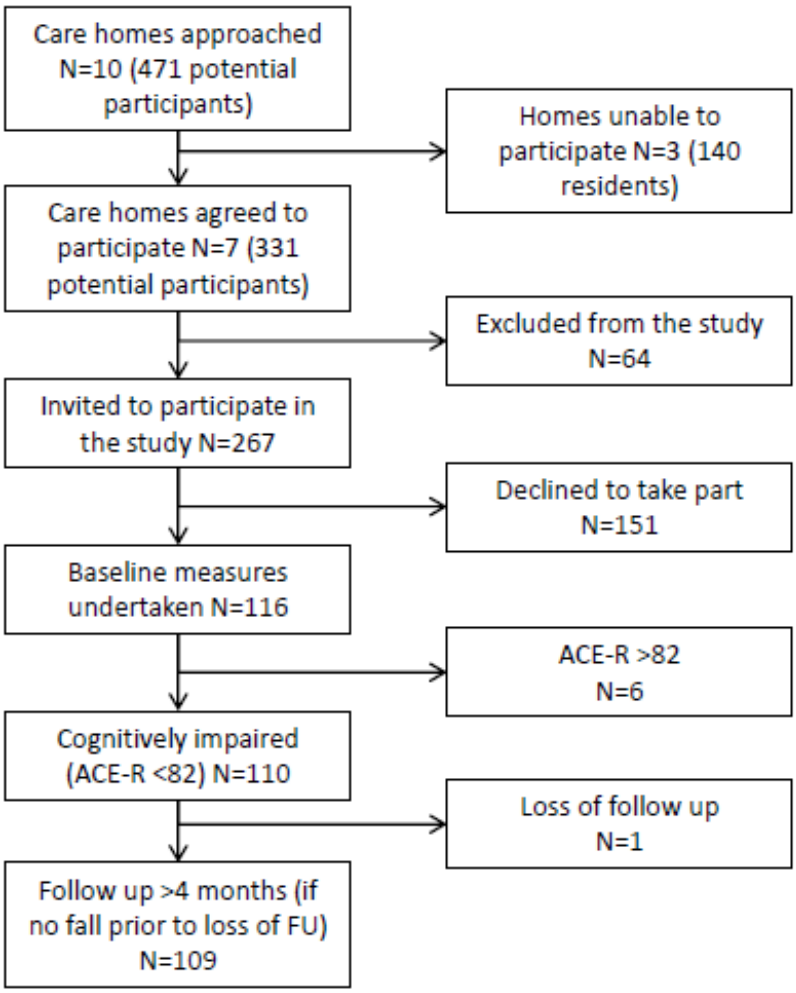


Table 4.2 Differences between those who took part, declined or were deemed unable

Variable	**Took part n=109 Mean (SD)**	**Declined to take part n=77 Mean (SD)**	**Deemed incapable of taking part n=54 Mean (SD)**
Age	84.5 (8.3)	82.1 (9.5)	84.5 (7.4)
Barthel (0-100)[a]	63.2 (25.0)	55.5 (26.7)	47.8 (24.5)
No of risk factor conditions[1]	1.6 (1.3)	1.6 (1.0)	1.5 (1.3)
No of medications	7.0 (3.5)	7.9 (3.6)	7.2 (3.4)
Sit to stand score (1-4)[b]	2.9 (0.7)	2.7 (0.6)	2.5 (0.7)
Balance score (1-6)	4.4(1.5)	4.1 (1.3)	4.1 (1.6)
MMSE (0-30)[c]	15.2 (7.3)	15.1 (6.9)	7.9 (3.4)
NPI (0-144)	15.7 (16.2)	18.8 (21.4)	21.2 (16.8)
Impulsivity and wandering	5.0 (3.4)	5.1 (3.3)	6.2 (3.4)
Falls in 6 months follow up	1.2 (2.2)	1.2 (1.9)	1.0 (1.3)

[1]=Conditions summed if present = stroke, hypertension, diabetes, arthritis, Parkinson's disease, previous hip fracture and depression, [a]= P=0.001, [b]=P=0.002, [c]=P<0.001

There was no difference in age, medical conditions, medication use, balance or behaviour between those who took part, those who declined and those deemed unable to take part. Those who were deemed unable to take part had significantly worse cognition measured using the MMSE and there was a gradual decline in function measured using the Barthel from those who took part to those deemed unable. There was no difference in the number of falls or fallers (took part n=53 (48.6%), declined n=36 (46.8%), unable n=32 (59.3%) X^2 2.24, P=0.33) between groups (Table 4.2).

4.3.1.2 Missing data

Definitions and methods used to calculate missing data are described in chapter 2 (page 124). Data missing at random ranged from none to 7 participants with a mean of 3% of data missing for this reason. Many tests were not limited by impaired cognition with a mean of 5 participants being unable to complete a test for this reason. Tests which were more affected by cognitive impairment were the hand reaction times and trail making tests which were not completed by 17% and 20% of participants respectively. Physical impairment was more likely than cognitive difficulties to result in missing data. A mean of 14 participants were unable to complete a test for this reason. The tests with most incomplete data included the timed sit to stand (which required participants to be able to stand from a chair without arms), measures of unsupported sway (required 30 seconds unsupported standing to complete test) and gait tests that required a certain distance to be covered (timed up and go and 6 metre walk). Table 4.3 provides more details.

Table 4.3 Details of missing data

Variable	Unable to do due to cognition	Unable to do due to physical impairment	Random missing
Barthel	0 (0%)	0 (0%)	0 (0%)
Lying /standing BP	0 (0%)	16 (15%)	7 (6%)
Medical condition	0 (0%)	0 (0%)	0 (0%)
Medications	0 (0%)	0 (0%)	0 (0%)
Timed up and go	4 (4%)	16 (15%)	4 (4%)
6 metre walk	4 (4%)	18 (17%)	4 (4%)
Sit to stand X5 time	0 (0%)	75 (68%)	0 (0%)
Standing balance	4 (4%)	18 (17%)	4 (4%)
MET	10 (9%)	0 (0%)	4 (4%)
Proprioception	5 (5%)	32 (29%)	3 (3%)
KES	5 (5%)	32 (29%)	3 (3%)
Grip strength	5 (5%)	0 (0%)	4 (4%)
Sway 1	9 (8%)	31 (28%)	4 (4%)
Sway 2	9 (8%)	39 (36%)	4 (4%)
Sway 3	9 (8%)	73 (67%)	4 (4%)
GAS	6 (6%)	0 (0%)	4 (4%)
GDS	6 (6%)	0 (0%)	7 (6%)
NPI	0 (0%)	0 (0%)	1 (1%)
Impulsivity	0 (0%)	0 (0%)	5 (5%)
ACE-R	3 (3%)	0 (0%)	0 (0%)
LMS	8 (7%)	1 (1%)	4 (4%)
BNT	6 (6%)	1 (1%	4 (4%)
SWWT	4 (4%)	18 (17%)	4 (4%)
Hand reaction times	19 (17%)	2 (2%)	4 (4%)
Trail making	22 (20%)	9 (8%)	4 (4%)
Overall mean	5.5 (5.2%)	14.6 (14%)	3.3 (3.2%)

4.3.1.3 Baseline data

4.3.1.3.1 Demographic, medical and environment

Demographics

Mean age was 84.5 ±8.3 ranging from 61-107. Sixty nine (63%) were female and most, 88%, were Caucasian (Caribbean=6%, African=3%, Mediterranean=2%, Asian =1%). Seventy four percent of the participants were born in the UK (10% Ireland, 5% Jamaica, 4% other European countries, 1% Africa, 1% Asia and 5% other or missing data). This was reflected in the fact that 75% spoke English as a first language.

Medical factors

Medical conditions

The conditions identified are listed using ICD10 classification in Table 4.4. The most common conditions were arthritis (48%), urinary incontinence (43%), hypertension (40%), diabetes (21%), stroke (21%), cataracts (18%) and depression (18%).

All of the participants had cognitive impairment, although only 33% had a diagnosis which included a cause and the remaining either had a diagnosis of unspecified dementia (25%) or no diagnosis but clear signs of cognitive impairment manifest in behaviour and ACE-R (42%) (Table 4.5).

Medical conditions associated with increased falls risk including stroke, hypertension, diabetes, arthritis, Parkinson's disease, previous hip fracture and depression were summed and a mean of 1.6 ±1.3 (range 0-5) of these conditions were present per person.

Table 4.4 Prevalence of medical conditions

Condition (recorded in care or medical notes) Using ICD10 classification	**Number of participants**	**% of sample**
I. Certain infectious and parasitic diseases		
Previous TB	3	3
II. Neoplasms		
Any cancer diagnosis	8	9
III. Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism		
Anaemia	6	6
IV. Endocrine, nutritional and metabolic diseases		
Diabetes	22	21
Hypercholesteraemia	8	7
Thyroid dysfunction	16	15
V. Mental and behavioural disorders*		
Depression	20	18
Schizophrenia	5	5
Hallucinations	2	2
Other mental health problems	7	6
Learning difficulties	1	1
VI. Diseases of the nervous system		
Epilepsy	2	2
Parkinson's disease	2	2
VII. Diseases of the eye and adnexa		
Cataracts	20	18

Condition (recorded in care or medical notes) **Using ICD10 classification**	**Number of participants**	**% of sample**
Macular degeneration	9	8
Glaucoma	5	5
Other eye condition	3	3
VIII. Diseases of the ear and mastoid process		
Diagnosed hearing impairment	4	4
IX. Diseases of the circulatory system		
Hypertension	44	40
Angina	7	6
Myocardial infarction	7	6
Ischaemic heart disease	8	7
Heart valve dysfunction / repair	1	1
Atrial fibrillation	11	10
Cardiac arrhythmias	3	3
Congestive cardiac/left ventricular failure	2	2
Stroke	23	21
Pacemaker	*5*	*5*
X. Diseases of the respiratory system		
COPD	6	6
Other respiratory problems	5	5
XI. Diseases of the digestive system		
Liver disease	2	2
Constipation	3	3
Other disease / surgery of digestive system	15	14
XII. Diseases of the skin and subcutaneous tissue		
Cellulitis	1	1
Leg ulcers / pressure sores	3	3
Other skin conditions	4	4
XIII. Diseases of the musculoskeletal system and connective tissue		
Arthritis	52	48
Joint replacement	7	6
Osteoporosis	13	12
XIV. Diseases of the genitourinary system		
Urinary incontinence	47	43
Gynae condition / gynae surgery	1	1
Prostrate problems	8	7
XVIII. Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified		
Syncope / collapse	2	2
XIX. Injury, poisoning and certain other consequences of external causes		
Hip#	11	10
Other lower limb #	4	4
Upper limb #	4	4
XXI. Factors influencing health status and contact with health services		
Alcohol misuse	8	7

* diagnoses of cognitive impairment detailed in table 4.5

Table 4.5 Prevalence of different diagnoses of cognitive impairment

	Number	Frequency
Alzheimer's disease	11	10%
Vascular dementia	8	7%
Mild cognitive impairment	3	3%
Alcohol related	3	3%
Stroke related cognitive impairment	3	3%
Lewy body dementia	0	0%
Dementia (cause not specified)	27	25%
No dementia diagnosis (but clinically cognitively impaired)	47	42%
Mixed aetiology	6	6%
Other dementias	1	1%

Falls in the previous year

Eighty nine (82%) of the participants had fallen in the previous year. There were a total of 229 falls recorded ranging between 1 and 15 falls per person (mean = 2). Of the fallers most (43%) had only one fall.

Lying / standing blood pressure

Lying standing blood pressure data was collected for 81 participants. Mean blood pressures and pulse rates for each test are provided in Table 4.6. Using the European guideline classifications of orthostatic hypotension (OH), there were 7 (6%) with classical OH, none of the participants had delayed OH and only 1 participant had postural orthostatic tachycardia syndrome.

Table 4.6 Details of blood pressure measurements

	Systolic (SD) / Diastolic (SD) mmHg	Pulse (SD) Bpm
Mean Lying	126 (21) / 70 (12)	72 (11)
Mean Standing (1min)	123 (21) / 70 (12)	82 (12)
Mean Standing (3mins)	135 (21) / 77 (12)	80 (13)
Mean change (lying – standing (1min))	+3.9 (19) / -0.6 (10)	+10.8 (8)
Mean change (Lying – standing (3mins))	-7.3 (18) / -6.3 (12)	+8.2 (8)
Mean change (standing 1min-3mins)	-12.1 (16) / -6.5 (11)	-2.3 (7)

Neurological/musculoskeletal examination procedure

One fifth (21%) of the participants had musculoskeletal abnormalities (loss of ROM, deformity, weakness) in upper limb and the same proportion had such abnormalities in the lower limbs. Twenty eight participants (26%) had positive neurological signs (on reflex, muscle tone, power and sensation testing).

Medications

The most commonly prescribed medications were antiplatelet drugs (50%), non-opioid analgesia (45%), lipid regulating drugs (39%), proton pump inhibitors (38%), osmotic laxatives (31%) and stimulant laxatives (27%). Just over one third (34%) of participants were prescribed calcium and vitamin D supplements and 22% bisphosphonates (Table 4.7). Participants were prescribed a mean of 7 ± 3.5 medications, ranging between 0 and 18.

Table 4.7 Medications used

Medication (using BNF code)	**Number of participants**	**% of sample**
1. Gastro-intestinal system		
1.1.2. Compound alginates	4	4
1.2. Antispasmodics	1	1
1.3.4. Prostaglandin analogues	1	1
1.3.5. Proton pump inhibitors	41	38
1.4.2. Anti-motility drugs	2	2
1.6.1. Bulk forming laxatives	4	4
1.6.2. Stimulant laxatives	29	27
1.6.4. Osmotic laxatives	34	31
2. Cardiovascular system		
2.1.1. Cardiac glycosides	6	4
2.2.4. Potassium-sparing diuretics with other diuretics	5	5
2.2.1. Thiazides and related diuretics	15	14
2.2.2. Loop diuretics	21	20
2.3.2. Drugs for arrhythmias	1	1
2.4. Beta-adrenoceptor blocking drugs	11	10
2.5.4. Alpha-adrenoceptor blocking drugs	2	2
2.5.5.1. Angiotensin-converting enzyme inhibitors	25	23
2.5.5.2. Angiotension-II receptor antagonists	4	4
2.6.1. Nitrates	5	5
2.6.2 Calcium channel blockers	24	22
2.6.3. Other antianginal drugs	1	1
2.8.1. Parenteral anticoagulant	1	1
2.9. Antiplatelet drugs	54	50
2.12. Lipid regulating drugs	42	39
Midodrine (not classified)	*7*	*6*

Medication (using BNF code)	Number of participants	% of sample
3. Respiratory system		
3.1.1.1. Selective B² agonists	8	7
3.1.2. Antimuscarinic bronchodilators	2	2
3.1.3. Theophylline	2	2
3.2. Corticosteroids	6	6
3.4.1. Antihistamines	5	5
3.9.1. Cough suppressants	1	1
3.9.2. Demulcent and expectorant cough preparations	1	1
4. Central nervous system		
4.1.1. Hypnotics	6	6
4.1.2. Anxiolytics	2	2
4.2.1. Antipsychotic drugs	17	16
4.2.3. Antimanic drugs	2	2
4.3.1. Tricyclic and related antidepressants	4	4
4.3.3. Selective serotonin re-uptake inhibitors	17	16
4.3.4. Other antidepressant drugs	7	6
4.6 Drugs used in nausea and vertigo	1	1
4.7.1. Non opioid analgesics	49	45
4.7.2. Opioid analgesics	9	8
4.8.1. Control of epilepsy	8	7
4.9.1. Dopaminergic drugs used in Parkinson's disease	1	1
4.11. Drugs for dementia	5	5
5. Infections		
5.1.1.2. Penicillinase resistant penicillins	2	2
5.1.2.1. Cephalosporins	1	1
5.1.5. Macrolides	1	1
5.1.8. Sulphonamides and trimethoprim	1	1
5.1.9. Antituberculosis drugs	1	1
6. Endocrine system		
6.1.1.2. Intermediate and long acting insulins	4	4
6.1.2.1. Sulphonylureas	11	10
6.1.2.2. Biguanides	5	5
6.2.1. Thyroid hormones	12	11
6.2.2. Antithyroid drugs	1	1
6.3.2. Glucocorticoid therapy	3	3
6.4.2. Male sex hormones and antagonists	4	4
6.6.2. Bisphosphonates and other drugs affecting bone metabolism	24	22
7. Obstetrics, gynaecology and urinary-tract disorders		
7.4.1. Drugs for urinary retention	4	4
7.4.2. Drugs for urinary frequency, enuresis and incontinence	3	3
8. Malignant disease and immuosuppression		
8.3.4.2. Gonadorelin analogues and gonadotrophin-releasing hormones	1	1
9. Nutrition and blood		
9.1.1.1. Oral iron	17	16
9.1.2. Drugs used in megaloblastic anaemias	16	15
9.2.1.2. Oral sodium and water	1	1
9.6.2. Vitamin B	11	10
9.6.3. Vitamin C	1	1
9.6.4. Vitamin D (and calcium)	37	34
9.6.7. Multivitamin preparations	5	5
10. Musculoskeletal and joint diseases		
10.1.1. Non-steroidal anti-inflammatory drugs	4	4
10.1.4. Gout and cytotoxic-induced hyperuricaemia	1	1
10.2.2. Skeletal muscle relaxants	1	1

Medication (using BNF code)	Number of participants	% of sample
10.3.2. Rubefacients and other topical antirheumatics	4	4
11. Eye		
11.3.1. Antibacterials	2	2
11.4.2. Other anti-inflammatory preparations	1	1
11.5 Mydriatics and cycloplegics	1	1
11.6 Treatment of glaucoma	5	5
11.8.1. Tear deficiency, ocular lubricants and astringents	4	4
12. Ear, nose and oropharynx		
12.1.3. Removal of ear wax	3	3
12.2.1. Drugs used in nasal allergy	2	2
12.2.3. Nasal preparations for infection	1	1
13. Skin		
13.2.1. Emollients	22	20
13.2.2. Barrier preparations	6	6
13.4. Topical corticosteroids	3	3
13.5.2. Preparations for psoriasis	2	2
13.9. Shampoos and other preparations for scalp and hair conditions	2	2
13.10.1.2. Antibacterial preparations also used systemically	3	3
13.10.2. Antifungal preparations	1	1
13.11.1. Alcohols and saline	1	1

Barthel

The mean Barthel score was 63/100 reflecting moderate functional impairment. Only 4% of participants were independent in every section of the Barthel. Most residents (84%) were independent feeding while only 19% were independent bathing and 6% on stairs. Most of the residents could transfer independently (75%) and over half mobilised independently (68%) (Table 4.8).

Table 4.8 Barthel data

	Mean (SD)	Median	Range	% independent
Total score /100	63.2 (25.0) Skew -0.69	70	10-100	4%
Feeding /10	9.1(2.1)	10	0-10	84%
Bathing /5	1.0 (2.0)	0	0-15	19%
Grooming /5	2.0 (2.4)	0	0-5	39%
Dressing /10	4.9 (4.5)	5	0-10	39%
Bowels /10	7.4 (3.9)	10	0-10	39%
Bladder /10	6.6 (4.2)	10	0-10	57%
Toilet use /10	7.0 (4.1)	10	0-10	61%
Transfers /15	13.0 (4.1)	15	0-15	75%
Mobility /15	11.6 (2.1)	15	0-15	68%
Stairs /10	0.7 (2.5)	0	0-10	6%

Environmental checklist

Environmental screening was conducted for 91 residents. Participants had a mean of 3.4 ±1.6 environmental risks in their room. The most common hazard was not having an adjustable chair (78%) while 40% had the call bell out of reach, 26% had worn ferrules on their walking aid and 25% could not easily reach their locker or table from the bed (Table 4.9). Most (65%) of residents wore slippers with no fixation (51%) and a small heel of between 0 and 2.5cm (99%) (Table 4.10).

Table 4.9 Results from environmental checklist

	N (%)		**N(%)**
Unsuitable bed height	21 (19)	Chair not adjustable	85 (78)
Call bell out of reach	44 (40)	Chair legs stick out	3 (3)
Unsuitable mattress	2 (2)	Chair not secure / sturdy	2 (2)
Locker or table out of reach	27 (25)	Resident cannot rise easily	17 (16)
No space for walking aid*	2 (2)	Cannot move foot rest	1 (1)
No locks or castors on beds	34 (31)	Brakes on the frame / wheelchair not working*	3 (3)
No access to night light	21 (20)	Walking aid incorrect height*	1 (1)
Cluttered room	7 (6)	Aid not placed within easy reach*	9 (8)
Cords or other trip hazards	4 (4)	Footplates not easy to move*	2 (2)
Loose rugs	11 (10)	Aid broken*	1 (1)
Unsuitable chair height	4 (4)	Ferrules worn*	28 (26)
No arm rests on chair	4 (4)	* if applicable	

Table 4.10 Footwear type, heel and fixation

Shoe type	**N (%)**	**Heel type**	**N (%)**
Slippers	60 (65%)	Small heel	91 (99%)
Sandal	11 (12%)	Medium heel	1 (1%)
Courtshoe	8 (9%)	**Fixation**	**N (%)**
Lace up shoes	5 (5%)	None	47 (51%)
Athletic shoes	3 (3%)	Laces	7 (8%)
Surgical boot	2 (2%)	Straps / buckles	3 (3%)
Other	3 (3%)	Velcro	35 (38%)

4.3.1.3.2 Mobility, balance and sensorimotor variables

Gait

Six metre walk

The mean 6 metre walk time was 39.4 seconds ± 40.8. Time taken ranged from 5-179 seconds and data was positively skewed with a score of 1.27 (SE 0.23). Distribution was improved with log transformation with a skew score of 0.35 (SE 0.23).

Timed up and go

The timed up and go test was performed in a mean time of 77seconds ±74.4 ranging between 11 and 275 seconds. The skew score was 1.1 (SE 0.23) which was improved by log transformation to 0.25 (SE 0.23).

Postural stability

Postural sway

Postural sway increased with the progressive difficulty of the standing balance situation. Twenty eight percent of participants could not stand on the floor with eyes open for 30 seconds, 36% were unable to stand with their eyes closed for 30 seconds and 67% unable to stand on foam for 30 seconds with their eyes open. These participants were given a score of 3SDs from the mean which was 6076, 5924 and 12384 respectively. These data were not highly skewed (Table 4.11).

Table 4.11 Postural sway in different conditions

	Mean (SD)	**Skew (SE)**	**Range**	**No. who could not stand 30 seconds [were given score 3SD above mean]**
Sway on floor eyes open	2404 (2413)	0.77 (0.23)	54-6076	31 (28%)
Sway on floor eyes closed	2819 (2415)	0.42 (0.23)	24-5934	39 (36%)
Sway on foam eyes open	9270 (4554)	-0.85 (0.23)	434-12384	73 (67%)

Sustaining standing positions

The mean standing balance score was 1.7 ±1.3. This equates to being able to stand for 7 seconds with feet side by side (within 1cm). Scores ranged from being unable to stand unsupported at all (score =0) to being able to stand in tandem for 10 seconds (score=6). Skew scores were low for this variable, 0.17 (SE 0.23). Examining which positions could be sustained for 10 seconds (Table 4.12), the largest proportion (29%) could not stand even with feet shoulder width apart. Only 2% could sustain a tandem standing position.

Table 4.12 Balance test scores

	N (%)
Unable to stand 10 seconds with feet apart	32 (29%)
Able to stand 10 seconds with feet apart (but not 10 seconds with feet together)	23 (21%)
Able to stand 10 seconds with feet together (but not 10 seconds in near tandem stand)	30 (28%)
Able to stand 10 seconds in near tandem standing (but not 10 seconds tandem stand)	22 (20%)
Able to stand 10 seconds tandem standing	2 (2%)

Strength

Grip strength

Mean grip strength was 11.1Kg ± 7.3 ranging between 1 and 37. Results were highly skewed with a skew score of 1.0 (SE 0.23). Log transformation improved the score with a skew score of -0.79 (SE 0.23).

Knee extension strength

Mean knee extension strength was 10.9Kg ±9.8 ranging between 0-46. Skew was moderate at 0.81 (SE 0.23).

Sit to stand test

Most participants could stand up independently. Fifty nine (54%) could stand from the chair using their arms and a further 34 (31%) could stand up with their arms crossed. Seven (6%)

could not stand at all and 9 (8%) needed assistance to stand. Mean score was 3.1 ±0.8. Those who were able to stand up without using their arms went on to perform the 5x sit to stand test. Those who were not tested because they were not able, were given a score 3SD longer than the mean score. Mean sit to stand time was 38.8 seconds ±13.2. Scores were negatively skewed with a skew score of -1.1 (SE 0.23).

Sensory function

Proprioception

Difference between foot placement on the proprioception test was a mean of 3.9 degrees ±2.4 apart ranging from accurate (no difference) to 9 degrees difference. Data for this variable was normally distributed (skew score 0.34 SE 0.23).

Vision

The mean score on the Melbourne Edge Test was 12.7 ±5.0 ranging over the full scale available between 1 and 24. Data for this test was normally distributed (skew -0.58, SE 0.23).

4.3.1.3.3 Behavioural and psychiatric symptoms

Impulsivity

The single question to determine whether a resident was impulsive or not, identified 18% as being impulsive. The individual questions identified evidence of impulsivity when sitting down on the chair/bed/toilet in 21%, before standing up in 18% and walking without help when asked not to in 15%. Twenty one percent of the residents demonstrated some wandering behaviours with (8%) wandering on a daily basis which was not alterable by care staff (see Table 4.13).

Table 4.13 Answers to impulsivity and wandering questions

Impulsivity / wandering question	**Mean (SD) Range**	**N (%)**	
1. Does …….. tend to be impulsive when moving around? [Impulsive means – rushes to carry out an activity without thinking about it first]	-	Yes	20 (18)
2.These are examples of impulsive behaviours could you tell me if …….. has demonstrated any of these behaviours?		Very frequently	3 (3%)
		Frequently	5 (4%)
a. Trying to sit down before getting right up to the seat / toilet / bed	1.4 (1.0)	Often	4 (4%)
		Occasionally	11(10%)
b. Attempting to stand before wheelchair footplates have been moved/ brakes applied /frame placed in front	1.4 (1.0)	Very frequently	5 (4%)
		Frequently	3 (3%)
		Often	3 (3%)
		Occasionally	9 (8%)
c. Trying to walk without help when they have been asked not to?	1.4 (1.0)	Very frequently	4 (4%)
		Frequently	5 (4%)
		Often	3 (3%)
		Occasionally	4 (4%)
3. Wandering score	0.6 (1.3)	-	
Total score	5.0 (3.4)	-	

Impulsivity scores were highly skewed (skew score=2.46 SE 0.23) which was not improved with log transformation (logged data skew score=1.32).

Anxiety

The mean Goldberg Anxiety Score was 2.24 ±2.47 with scores ranging between 0 and the maximum score of 9. The skew score was 0.98 (SE0.23). Just under half (44%) scored 2 or more on the scale which is the "cut point" suggesting a state of anxiety.

Depression

The mean score on the geriatric depression scale was 4.99 ±3.08 with scores ranging from 0 to 14 out of a potential 15. The skew score was 0.60 (SE 0.23). More than half of the residents tested (55%) scored 5 or more on this test which suggests they had symptoms of depression.

Neuropsychiatric inventory

Most (84%) of the participants had some behavioural problems identified using the neuropsychiatric inventory. The mean score was 15.7 ±16.2 suggesting most problems were mild. In fact the maximum score was 75 out of a possible 144 points. The most common behaviours exhibited were irritability, anxiety and depression which affected nearly half the participants. Elation and appetite problems were relatively rare, affecting only 11% and 9% of residents respectively (see Table 4.14).

Due to the predominance of low scores the distribution of this data was positively skewed with a skew score of 1.4 (SE 0.23). Log transformation did not improve the distribution of the data with a skew score of transformed data of -1.1 (SE 0.23).

Table 4.14 Neuropsychiatric inventory

Category	**Mean score (SD)**	**No with identified problem (%)**	**Mean score of those with this behaviour**	**Proportion in each category* (out of total sample)**	
Delusions	0.86 (2.38)	25 (23%)	3.77 (1.12)	Minor	16%
				Mod	4%
				Severe	4%
Hallucinations	0.36 (1.41)	14 (13%)	3.00 (3.06)	Minor	10%
				Mod	2%
				Severe	1%
Agitation	1.88 (3.32)	35 (38%)	5.38 (3.57)	Minor	13%
				Mod	13%
				Severe	9%
Depression	1.51 (2.72)	43 (40%)	3.83 (3.16)	Minor	22%
				Mod	13%
				Severe	5%
Anxiety	2.05 (3.38)	45 (41%)	4.98 (3.63)	Minor	17%
				Mod	15%
				Severe	9%
Elation	0.36 (1.35)	13 (11%)	3.25 (2.77)	Minor	7%
				Mod	3%
				Severe	1%
Apathy	1.82 (3.46)	36 (33%)	5.52 (3.98)	Minor	12%
				Mod	12%
				Severe	9%
Disinhibition	1.37 (2.75)	35 (32%)	4.27 (3.37)	Minor	18%
				Mod	7%
				Severe	6%
Irritability	2.14 (3.42)	46 (42%)	5.07 (3.58)	Minor	16%
				Mod	18%
				Severe	8%

Category	Mean score (SD)	No with identified problem (%)	Mean score of those with this behaviour	Proportion in each category* (out of total sample)	
Motor disturbance	1.65 (3.42)	29 (26%)	6.20 (3.98)	Minor	9%
				Mod	7%
				Severe	10%
Night time	1.34 (3.00)	28 (26%)	5.23 (3.87)	Minor	10%
				Mod	9%
				Severe	7%
Appetite	0.33 (1.52)	10 (9%)	3.89 (3.95)	Minor	6%
				Mod	1%
				Severe	2%
Total score	15.69 (16.18)	92 (84%)			

*Minor = 1-3, Moderate = 4-8, Severe = 9+ points

4.3.1.3.4 Neuropsychological measures

The mean score on the Addenbrooke's Cognitive Examination (ACE-R) was 40.30 ±21.30 with scores ranging from 0-81 out of a possible 100. A score of <82 is indicative of cognitive impairment, therefore all participants fulfilled these criteria. This data was normally distributed with a skew score of 0.01(SE0.23).

Orientation and attention

In all questions on attention and orientation, scores ranged throughout the available scale. The mean score for orientation to time was 1.53 ±1.63, orientation to place was 2.26 ±1.66, registration of 3 objects 2.45 ±0.99 and for attention and calculation (serial 7s/world backwards) was 2.55 ±2.02. The mean total score for attention and orientation was 8.78 ±5.08 out of a possible 18. The total score was normally distributed (skew score 0.1 SE 0.23).

Memory

Of the memory questions in the ACE-R, the mean score for recall of the three objects was 0.72 ±1.02. Mean recall of the 7 item name and address immediately after 3 repetitions was 3.79 ±2.30), mean recall of the same items at the end of the test was 0.37 ±1.04 and mean recognition score was 1.87 ±1.73. The mean score for the 4 retrograde memory tests was 1.15

±1.28. The total score for the memory section of the ACE-R was 7.91 ±5.73 out of a possible 26. Data were slightly positively skewed with a skew score of 0.71 (SE 0.23).

The mean number of components of the logical memory story recalled immediately after telling the story was 3.03 ±3.05 out of a possible 25. This decreased to 1.43 ±2.25 25-30 minutes later.

Both logical memory tests were positively skewed. The immediate recall having a skew score of 0.99 (SE 0.23) and the delayed a score of 1.91 (SE 0.23). Log transformation improved the distribution of the immediate recall (skew score -0.59) but not the delayed recall (-1.24).

Processing speed

The mean hand reaction time was 505.12 milliseconds (ms) ±310.26 with times ranging from 143-1384ms. The reaction time data was positively skewed (skew score 1.17) which was improved with log transformation (skew score 0.61).

Speed of executive function

The mean time taken to complete the trail making test was 214.27 seconds ±83.9 ranging between 59 and the cut off of 300 seconds. Distribution of data in this sample were reasonably distributed with a skew score of -0.43.

Visuospatial function

For each of the individual components of the ACE-R that tested visuospatial function the mean scores were as follows; overlapping pentagons was 0.29 ±0.45 out of 1, cube was 0.39 ±0.61 out of 2, the clock test was 1.33 ±1.46 out of 5, dots was 2.25 ±1.73 out of 4 and letters was 2.77 ±1.77 out of 4. The mean total score for visuospatial tests was 7.03 ±4.92 out of a possible 16. Data were only slightly negatively skewed with a score of -0.23 (SE 0.23).

Language

Details of the breakdown in language scores from the ACE-R are provided in Table 4.15. In the ACE-R the language components are broken down into two scores; fluency and language. The mean total fluency score was 3.20 ±2.99 out of 14 and the language score 13.46 ±6.59 from a possible 26. Both samples were not excessively skewed (skew scores of 0.62 and -0.40 respectively). The mean score on the Boston naming test was 4.78 ±4.25 with scores ranging between 0 and the maximum of 15. The skew score for this test was 0.55 (SE 0.23).

Table 4.15 Breakdown of language scores on ACE-R

Test	Mean (SD)	Maximum score
Verbal fluency	3.20 (2.99)	14
Language comprehension 1	0.79 (0.40)	1
Language comprehension 2	2.11 (0.94)	3
Writing	0.51 (0.50)	1
Repetition	1.60 (1.37)	4
Naming	6.60 (3.78)	12
Comprehension	1.40 (1.22)	4
Reading	0.44 (0.49)	1

Dual tasking

Twenty six (24%) participants stopped walking when questioned in the "stops walking when talking test".

4.3.1.3.5 Falls follow up

Those who were followed up for ≥4 months or fell before loss to follow up were included in the analysis. Of these, the mean length of follow up was 5.9 months ±0.76 ranging from 1 to 8 months. Ninety two percent of the participants completed the six month follow up. Reasons for loss to follow up before this time included death n=4 (4%), admission to hospital n=3 (3%) and transfer to another care home n=2 (2%).

Fifty six participants (48.6%) fell one or more times during the follow up period. Twenty eight (25.7%) of the participant fell 2 or more times (multiple fallers).

Table 4.16 Circumstances of falls

	N (%)
Falls indoors	
Standing, walking, turning	40 (31%)
Getting on/off the bed, chair or toilet	71 (56%)
Stairs	1 (0.8%)
Other	12 (9%)
Falls in the garden	
On the path	1 (0.8%)
Stairs	1 (0.8%)
Falls outside the home	
In the street	1 (0.8%)
In a public building	1 (0.8%)
Total	172 (100%)

Of the fallers, the number of falls ranged between 1 and 16 per person. The mean number of falls in this group was 2.4 ±2.4. The total number of falls sustained was 127 resulting in a falls rate of 2.6 ±4.7 falls per person per year.

The vast majority of falls occurred indoors and half (56%) occurred while getting on/off a chair, bed or toilet. Most of the other falls (31%) occurred while standing, walking or turning (Table 4.16).

Table 4.17 Location of falls

Location	**N (%)**
Bedroom (own)	76 (60%)
Day room	26 (20%)
Bathroom (own)	9 (7%)
Corridor	8 (6%)
Bathroom (other)	1 (1%)
Bedroom (other)	1 (1%)
Stairs	3 (3%)
Other	3 (2%)
Total	127 (100%)

In terms of location, more than half of all falls occurred in the residents' own rooms (60%) with a further 29% falling in communal rooms (Table 4.17). Most of the falls (31%) were unwitnessed and the resident was not able to provide a reason for the fall (i.e. they were found on the floor). Following this, common reasons given for falls included loosing balance (18%), tripping (13%) and slipping (8%) (Table 4.18).

Table 4.18 Causes of falls

Reason	**N (%)**
Trip	17 (13)
Slip	11 (8)
Felt giddy/faint	2 (2)
Lost balance	23 (18)
Legs gave way	10 (9)
Not sure, suddenly on the floor*	17 (13)
Found on the floor, no explanation	40 (31)
Other	7 (6)
Total	127 (100)

* Reported by resident

Most residents could not get up independently following the fall with 64% requiring assistance from carers and another 33% needing hoisting (Table 4.19).

Table 4.19 How did they get up?

Method	N (%)
Got up independently	6 (5)
Hoist required	43 (33)
Physical help from carer required	65 (64)
Other	15 (12)
Total	127 (100)

Of the fallers, 22 (42%) sustained an injury with 1 (4%) sustaining a fracture and 20 (38%) minor injuries (cuts, bruises, sprains and pain) (Table 4.20).

Fifty four fall events (43%) required some sort of healthcare intervention. Most falls related injuries only required treatment by care home staff (17%) but 11% required a GP visit, 6% attendance at the emergency department and 3% a hospital admission (Table 4.20).

Table 4.20 Fall related injuries and treatment required

Injuries sustained	N (%)	Treatment required	N (%)
No injury	93 (73)	No healthcare needed	73 (57)
Cuts	14 (11)	Care home staff provided care	21 (17)
Bruises	14 (11)	GP visit	15 (11)
Pain	2 (2)	Emergency department visit	7 (6)
Fracture	4 (3)	Hospital admission	4 (3)
		Not known / recorded	7 (6)
Total	127 (100)	Total	127 (100)

Falls occurred at all times during the day. The highest frequency of falls was between 8 and 9am when 11 falls occurred and then between 6 and 7am when 10 falls occurred (Figure 4.2). When the day was broken down into different periods, the early morning saw the highest frequency of falls with 8 falls per hour, whereas the lowest frequency was during the night with a mean of 4 falls per hour (Figure 4.3).

Figure 4.2 Number of falls by hour

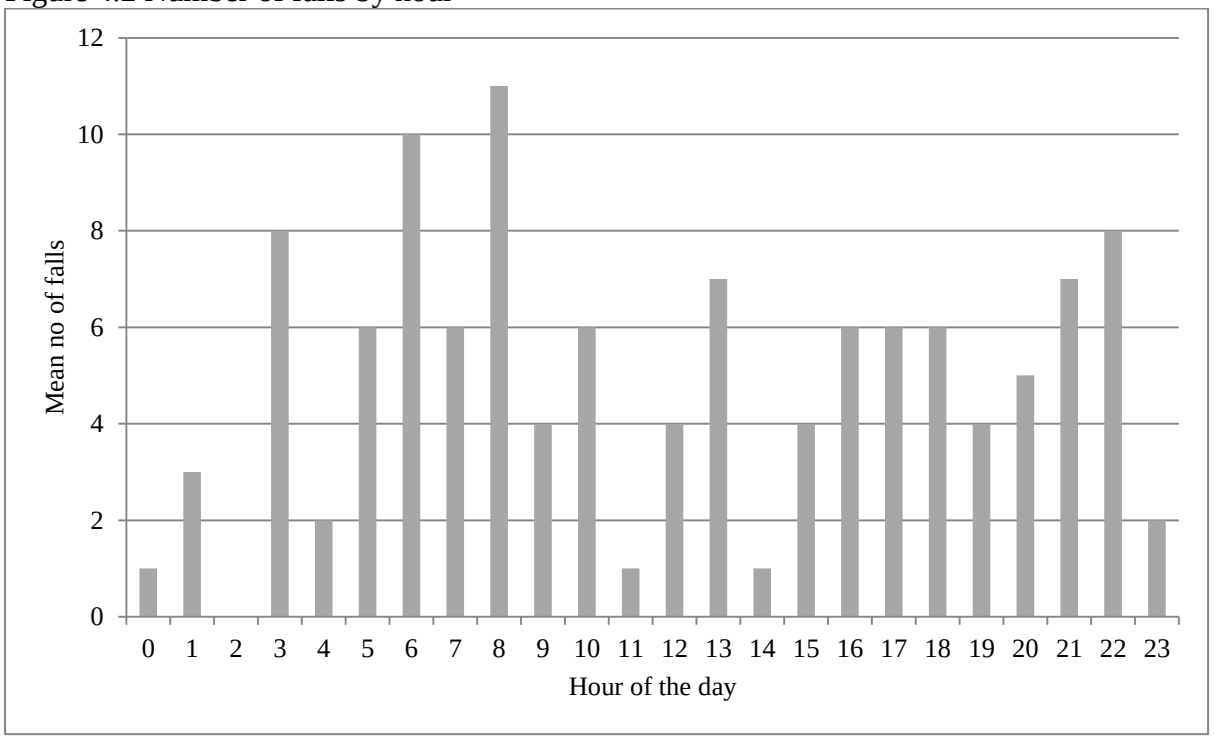
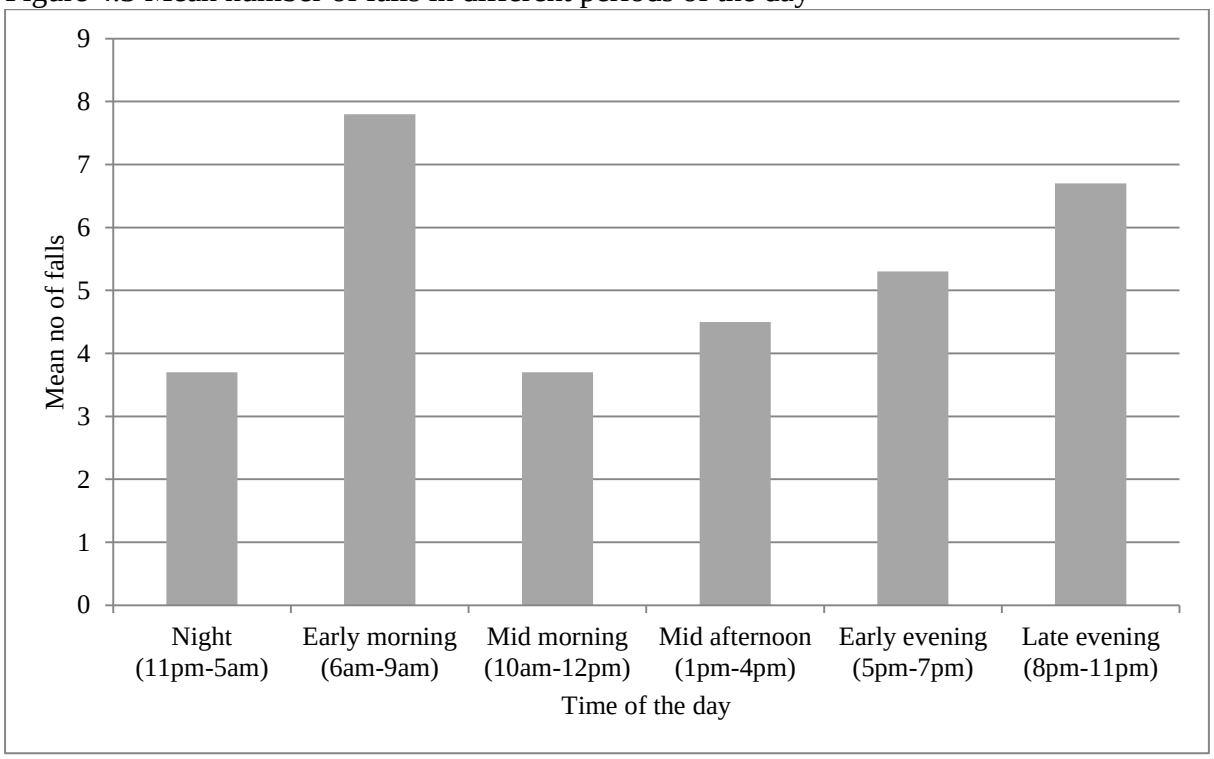


Figure 4.3 Mean number of falls in different periods of the day



4.3.1.4 Relationships between the baseline variables

Significant correlations between the baseline variables used in this study are presented in Table 4.21. The highest r was 0.75 which indicates there was no problem with collinearity in the measurements used. There were significant relationships between function (Barthel) and the balance and physiological profile assessment scores. There were also significant correlations between timed up and go and balance and sit to stand scores. The greater the extent of cognitive impairment, the more likely the resident was to exhibit dementia related behaviours (NPI) and be impulsive.

Table 4.21 Correlations between variables

Variable	Correlated variable	R	P value
Function (Barthel)	No of medical conditions	-0.21	0.028
	No of medications	-0.24	0.013
	Depression (GDS)	-0.29	0.003
	Cognition (ACE-R)	0.28	0.004
	Processing speed (trail making test)	-0.29	0.002
	Hand reaction time	-0.31	0.001
	Knee extension strength	0.56	<0.001

Variable	Correlated variable	R	P value
	Proprioception	-0.46	<0.001
	Sway eyes open on the floor	-0.58	<0.001
	Sway eyes closed on the floor	-0.55	<0.001
	Sway eyes open on the foam	-0.27	0.005
	PPA	-0.42	<0.001
	Grip strength	0.27	0.005
	Timed up and Go	-0.68	<0.001
	6m walk	-0.71	<0.001
	Sit to stand score	0.69	<0.001
	Sit to stand time	-0.46	<0.001
	Total balance score	0.75	<0.001
Behaviour (Neuropsychiatric Inventory)	Impulsivity	0.47	<0.001
	Anxiety (GAS)	0.36	<0.001
	Cognition (ACE-R)	-0.35	<0.001
	Logical memory story	-0.24	0.011
	Trail making test	0.23	0.014
	Hand reaction time	0.36	<0.001
	PPA	0.32	0.001
Anxiety (GAS)	Neuropsychiatric inventory	0.36	<0.001
	Depression	0.45	<0.001
	Sway eyes open on the foam	0.23	0.017
	PPA	0.23	0.015
Depression (GDS)	Barthel	-0.29	0.003
	No of medical conditions	0.29	0.003
	No of medications	0.21	0.028
	Anxiety (GAS)	0.47	<0.001
	Logical memory score	0.22	0.019
	Melbourne edge test	-0.20	0.033
	Knee extension strength	-0.22	0.019
	Sway eyes closed on the floor	0.19	0.048
	Timed up and go	0.25	0.008
	6m walk	0.28	0.003
	Total balance score	-0.26	0.006
	PPA	0.22	0.020
Cognition (ACE-R)	Barthel	0.28	0.004
	Neuropsychiatric inventory	-0.35	<0.001
	Impulsivity	-0.27	0.005
	Logical memory story	0.60	<0.001
	Boston naming test	0.46	<0.001
	Melbourne edge test	0.33	0.001
	Hand reaction time	-0.51	<0.001
	6 metre walk	-0.20	0.033
	PPA	-0.50	<0.001
Gait (timed up and go)	Depression (GDS)	0.25	0.008
	Hand reaction time	0.35	<0.001
	Knee extension strength	-0.56	<0.001
	Proprioception	0.54	<0.001
	Sway eyes open on the floor	0.65	<0.001
	Sway eyes closed on the floor	0.57	<0.001
	Sway eyes open on the foam	0.27	0.005
	Grip strength	-0.31	0.001
	6 metre walk	0.90	<0.001
	Sit to stand score	-0.70	<0.001
	Sit to stand time	0.49	<0.001
	Total balance score	-0.72	<0.001
	PPA	0.43	<0.001
	Processing speed (trail making test)	0.29	0.002
Sit to stand score	Knee extension strength	0.46	<0.001
	Proprioception	-0.43	<0.001
	Sway eyes open on the floor	-0.55	<0.001
	Sway eyes closed on the floor	-0.55	<0.001
	Sway eyes open on the foam	-0.22	0.021
	Grip strength	0.27	0.005
	Timed up and go	-0.70	<0.001
	6m walk	-0.65	<0.001
	Sit to stand time	-0.71	<0.001
	Total balance scores	0.67	<0.001
Balance (total balance score)	Barthel	0.75	<0.001

Variable	Correlated variable	R	P value
	No of medical conditions	-0.22	0.022
	No of medications	-0.25	0.009
	Depression (GDS)	-0.26	0.006
	Melbourne edge test	0.20	0.035
	Hand reaction times	-0.23	0.015
	Knee extension strength	0.57	<0.001
	Proprioception	-0.44	<0.001
	Sway eyes open on the floor	-0.68	<0.001
	Sway eyes closed on the floor	-0.67	<0.001
	Sway eyes open on the foam	-0.38	<0.001
	Grip strength	0.27	0.004
	Timed up and go	-0.72	<0.001
	6 metre walk	-0.74	<0.001
	Sit to stand score	0.67	<0.001
	Sit to stand time	-0.56	<0.001
	PPA	-0.43	<0.001
	Processing speed (trail making test)	-0.33	<0.001
PPA	Barthel	0.75	<0.001
	Neuropsychiatric inventory	0.32	0.001
	Impulsivity	0.21	0.30
	Anxiety (GAS)	0.29	0.002
	Depression (GDS)	0.22	0.020
	ACE-R	-0.50	<0.001
	Logical memory story	-0.34	<0.001
	Boston naming test	-0.24	0.011
	Processing speed (trail making test)	-0.33	<0.001
	Grip strength	-0.24	0.012
	Timed up and go	0.43	<0.001
	6m walk	0.40	<0.001
	Sit to stand score	-0.22	0.020
	Sit to stand time	0.30	0.001
	Total balance score	-0.43	<0.001

4.3.1.5 Differences between the screening and detailed data collection cohort

Data collected from the screening study (chapter 3) were compared to the data from this study. Those who participated in the screening study were more functionally impaired, less able to sit to stand, more likely to have fallen in the previous year, more likely to be in a unit with nursing care and more likely to have urinary incontinence. There were no significant differences in other measures (Table 4.22).

Table 4.22 Differences between the screening and in-depth data collection studies

	Readily available data only N=131	Detailed study N=109	P value
Number of risk related medical conditions[1]	1.56 (1.14)	1.59 (1.27)	0.89
Number of medications	7.59 (3.54)	7.01 (3.49)	0.21
Barthel	52.34 (26.00)	63.19 (25.00)	0.001
Care staff balance question†	4.13 (1.38)	4.42 (1.51)	0.073
Care staff sit to stand question†	2.61 (0.63)	2.89 (0.66)	<0.001
Impulsivity and wandering index‡	5.54 (3.38)	4.96 (3.36)	0.078
NPI‡	19.80 (19.59)	15.67 (16.18)	0.14
MMSE	12.14 (6.69)	15.19 (7.27)	0.21

† Analysis used the Mann-Whitney test as data ordinal
‡ Analysis used the Mann-Whitney test as data skewed which was not improved by log transformation
[1] Conditions summed if present = stroke, hypertension, diabetes, arthritis, Parkinson's disease, previous hip fracture and depression

4.3.1.6 Faller status

4.3.1.6.1 Univariate analysis

The screening study (chapter 3) which included this cohort, identified more significant differences between fallers and non-faller compared to multiple versus non-multiple fallers. Therefore any fall (≥1) was used as the falls outcome in this study.

Continuous variables

Fallers had more risk related medical conditions, were slower on the 6 metre walk and timed up and go, had worse sit to stand scores, were more impulsive, more anxious and had higher NPI scores. Fallers had lower scores on the ACE-R and on the subsections of the ACE-R of attention and orientation and fluency.

When data was adjusted for multiple tests using the Bonferroni adjustment (31 tests for alpha <0.05 p needed to be <0.002), the only significant difference was in sway with eyes closed.

There was no age difference between fallers and non-fallers (a mean age of 84.2 (SD 8.25) for fallers and 83.2 ±8.89 for non-fallers (t=-0.92, df=238, p=0.36)) (Table 4.23).

Table 4.23 Differences between fallers and non-fallers in continuous data

Variable	Non fallers N=56	Fallers N=53	P value
DEMOGRAPHIC AND MEDICAL			
Number of medical conditions[1]	1.32 (1.13)	1.87 (1.36)	0.024
Number of medications	6.43 (3.36)	7.62 (3.55)	0.074
Barthel	67.27 (24.49)	58.87 (25.01)	0.079
Mean change in systolic BP	+3.28 (14.61)	+2.57 (18.10)	0.82
Environment score	3.28 (1.57)	3.43 (1.66)	0.65
SENSORI-MOTOR, GAIT AND BALANCE			
6 metre walk (seconds) §	31. 27 (35.34)	48.06 (44.60)	0.023
Timed up and Go (seconds) §	62.85 (70.27)	92.03 (76.26)	0.022
Sway on floor eyes open (mm^2)	1743.31 (2064.28)	3102.52 (2573.39)	0.003
Sway on floor eyes closed (mm^2)	2113.12 (2143.19)	3564.15 (2490.27)	0.001
Sway on foam eyes open (mm^2)	8170.48 (4867.26)	10432.77 (3916.12)	0.009
Sustaining standing positions†	2.02 (1.26)	1.39 (1.19)	0.018
Grip strength §	11.75 (8.10)	10.32 (6.44)	0.55
Knee extension strength (Kg)	12.25 (9.86)	9.47 (9.65)	0.14
Sit to stand score †	3.25 (0.75)	2.94 (0.84)	0.044
Sit to stand time (seconds) ‡	36.75 (13.93)	40.91 (12.08)	0.143
Proprioception (degrees)	3.66 (2.21)	4.05 (2.58)	0.39
Vision	12.87 (4.44)	12.50 (5.48)	0.70
PPA fall risk score	5.10 (1.91)	5.91 (2.20)	0.072
BEHAVIOURAL AND PSYCHIATRIC SYMPTOMS			
Impulsivity (including wandering)‡	4.37 (2.95)	5.59 (3.68)	0.002
Anxiety (GAS)	1.57 (1.76)	2.96 (2.89)	0.003
Depression (GDS)	4.60 (2.61)	5.41 (3.94)	0.17
Neuropsychiatric inventory‡	11.64 (14.31)	19.96 (17.05)	0.005
Wandering (only)	0.41 (1.00)	0.76 (1.45)	0.29
NEUROPSYCHOLOGICAL			
ACE-R	44.91 (21.98)	35.58 (19.63)	0.022
Logical memory§	3.16 (2.95)	2.90 (3.18)	0.45
Logical memory delayed‡	1.52 (2.33)	1.34 (2.18)	0.57
Boston naming test	4.77 (4.26)	4.78 (4.28)	0.99
Hand reaction times§	476.73 (292.19)	535.12 (328.39)	0.42
Trail making test	209.83 (87.94)	218.96 (79.75)	0.57

[1] Conditions summed if present = stroke, hypertension, diabetes, arthritis, Parkinson's disease, previous hip fracture and depression

† Analysis used the Mann-Whitney test as data ordinal

‡ Analysis used the Mann-Whitney test as data skewed which was not improved by log transformation

§ T test performed on log transformed data

The individual scores of the ACE-R, Barthel, NPI were compared to determine which sections were different between fallers and non-fallers. In the ACE-R, fallers performed worse in domains of attention and orientation, memory and verbal fluency. Fallers had worse orientation to time, attention and calculation, anterograde memory, writing and drawing

pentagons. The only difference on Barthel scores was that fallers had lower feeding scores and in the NPI higher irritability scores (Table 4.24,Table 4.25 and Table 4.26).

Table 4.24 Breakdown of ACE-R scores between fallers and non-fallers

Variable	Non fallers N=56 Mean (SD)	Fallers N=53 Mean (SD)	P value
Orientation to time /5	1.86 (1.69)	1.17 (1.50)	0.026
Orientation to place /5	2.41 (1.76)	2.09 (1.52)	0.33
Registration /3	2.55 (0.93)	2.34 (1.06)	0.26
Attention and calculation /5	3.13 (1.92)	1.92 (1.96)	0.002
Total orientation/attention /18	9.96 (5.06)	7.53 (4.84)	0.012
Recall/3	0.81 (1.05)	0.62 (0.99)	0.33
Anterograde memory (immediate) /7	4.19 (2.14)	3.36 (2.40)	0.057
Anterograde memory delayed /7	0.57 (1.34)	0.17 (0.51)	0.045
Anterograde memory recognition /5	2.16 (1.68)	1.57 (1.75)	0.073
Retrograde memory /4	1.29 (1.37)	1.00 (1.78)	0.23
Total memory /26	9.03 (5.97)	6.71 (5.26)	0.034
Verbal fluency /14	3.89 (3.09)	2.47 (2.72)	0.013
Comprehension instructions 1 /1	0.81 (0.39)	0.77 (0.42)	0.59
Comprehension instructions 2 /3	2.11 (0.91)	2.11 (0.98)	1.00
Writing /1	0.63 (0.48)	0.38 (0.49)	0.008
Repetition /4	1.85 (1.35)	1.34 (1.36)	0.054
Naming /12	6.85 (3.80)	6.34 (3.78)	0.48
Comprehension of pictures /4	1.52 (1.23)	1.28 (1.20)	0.32
Reading /1	0.41 (0.49)	0.47 (0.50)	0.51
Total language /26	14.18 (6.66)	12.70 (6.49)	0.24
Pentagons /1	0.40 (0.49)	0.17 (0.38)	0.006
Cube /2	0.55 (0.68)	0.23 (0.47)	0.004
Clock /5	1.53 (1.53)	1.11 (1.35)	0.3
Dots /4	2.46 (1.64)	2.04 (1.81)	0.20
Letters /4	2.91 (1.69)	2.62 (1.86)	0.40
Total visuospatial /16	7.85 (5.02)	6.17 (4.72)	0.074

Table 4.25 Breakdown of Barthel scores between fallers and non-fallers

	Non-faller Mean(SD) =56	Faller Mean(SD) =53	P value
Feeding (0-10)	9.54 (1.44)	8.67 (2.02)	0.036
Bathing (0-5)	1.09 (2.07)	0.87 (1.89)	0.57
Dressing (0-10)	5.54 (4.64)	4.26 (4.21)	0.13
Grooming (0-5)	2.35 (2.50)	1.64 (2.35)	0.13
Bladder function (0-10)	6.52 (4.26)	6.70 (4.27)	0.83
Bowel function (0-10)	7.59 (3.93)	7.17 (3.86)	0.58
Toilet (0-10)	7.73 (3.67)	6.19 (4.46)	0.053
Transfers (0-15)	13.55 (3.78)	12.34 (4.44)	0.13
Mobility (0-15)	12.35 (5.47)	10.71 (5.97)	0.14
Stairs (0-10)	0.71 (2.60)	0.66 (2.41)	0.054

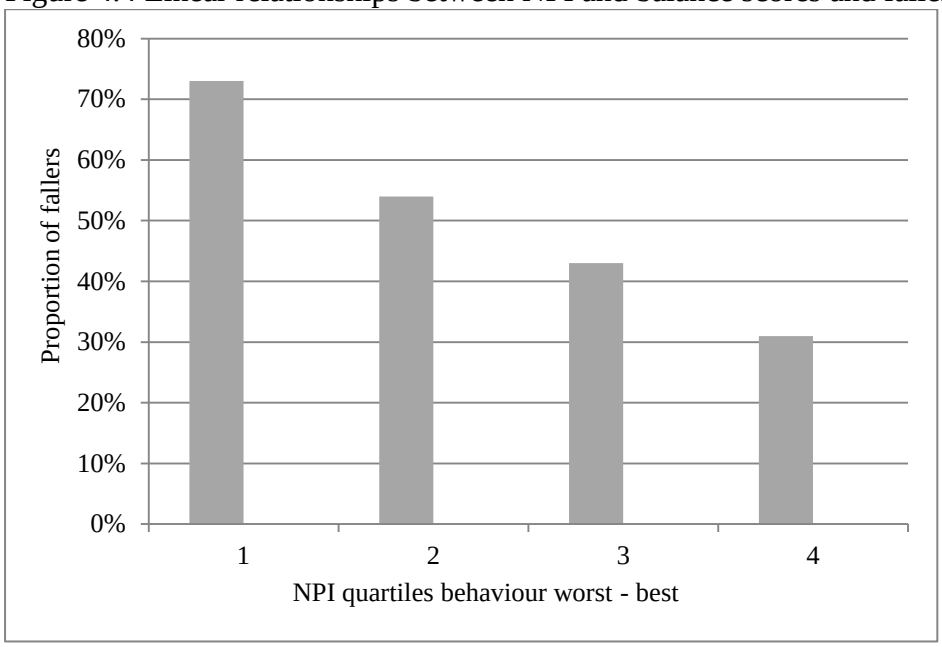
Table 4.26 Breakdown of NPI scores between fallers and non-fallers

	Non-faller Mean(SD) =56	**Faller Mean(SD) =53**	**P value (Mann-Whitney)**
Delusions	0.95 (2.74)	0.77 (1.96)	0.33
Hallucinations	0.21 (0.70)	0.53 (1.89)	0.47
Agitation	1.63 (3.11)	2.13 (3.54)	0.65
Depression	1.26 (2.31)	1.77 (3.11)	0.90
Anxiety	1.77 (3.32)	2.36 (3.45)	0.45
Elation	0.42 (1.50)	0.30 (1.19)	0.45
Apathy	1.18 (3.00)	2.51 (3.79)	0.009
Disinhibition	1.08 (2.41)	1.68 (3.07)	0.34
Irritability	1.27 (2.66)	3.06 (3.89)	0.008
Motor behavior	1.16 (3.01)	2.17 (3.76)	0.46
Night time disturbance	0.67 (1.94)	2.86 (3.70)	0.14
Appetite	0.04 (0.20)	0.62 (2.14)	0.13

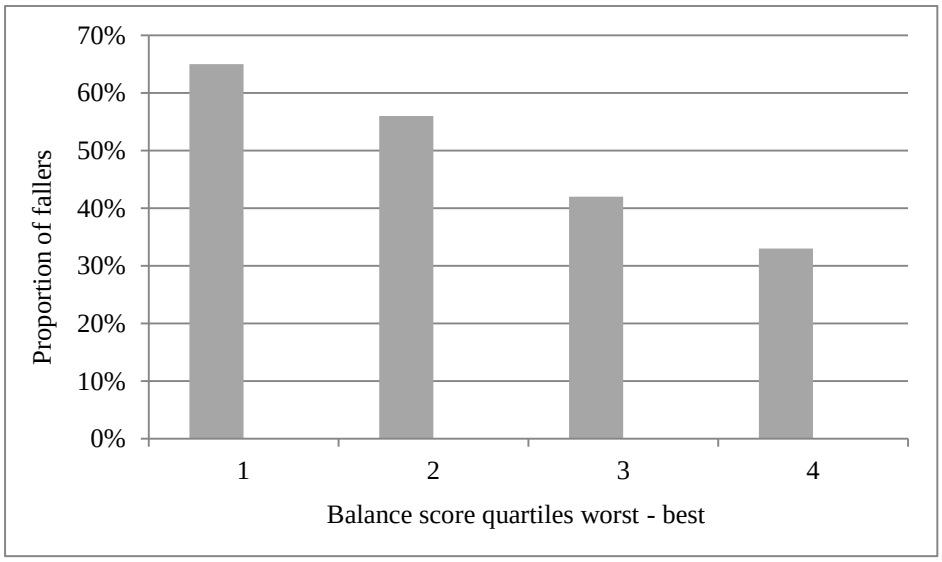
Linear / non-linear relationships

There was a linear increase in fallers with worsening performance in the balance and NPI scores (Figure 4.4). In the GAS, ACE-R and Barthel there appeared to be a threshold effect where no further increases in proportions of fallers were seen after a certain point (Figure 4.5). There was evidence of non-linear patterns in both the 6m walk and timed up and go tests where fallers decreased as performance improved until the highest quartile where the incidence of falls increased again (Figure 4.6).

Figure 4.4 Linear relationships between NPI and balance scores and faller status

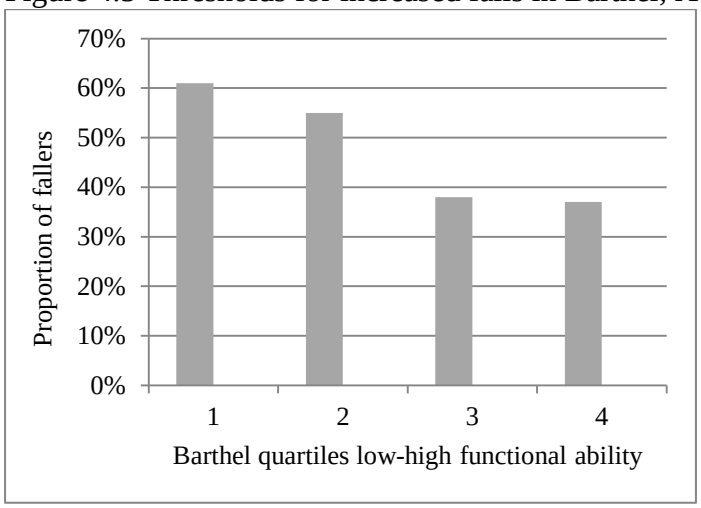


NPI scores per quartile. 1 >24, 2= 23-12, 3= 11-2, 4 <2

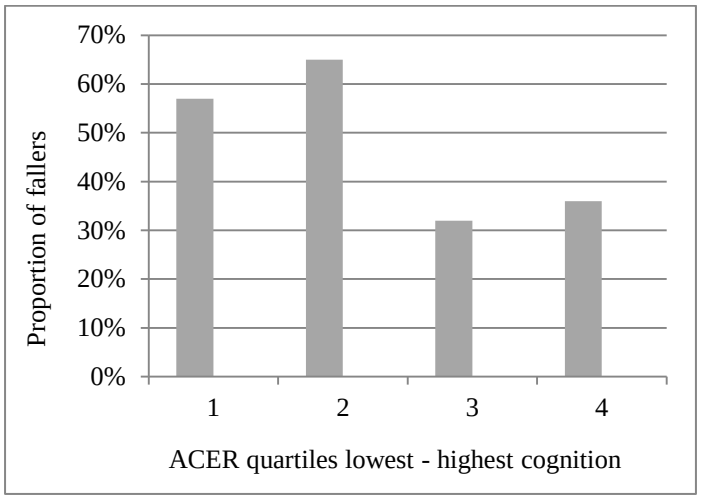


Balance scores per quartile. 1 <0.4, 2= 0.5-2.0, 3= 2.1-2.6, 4 >2.6

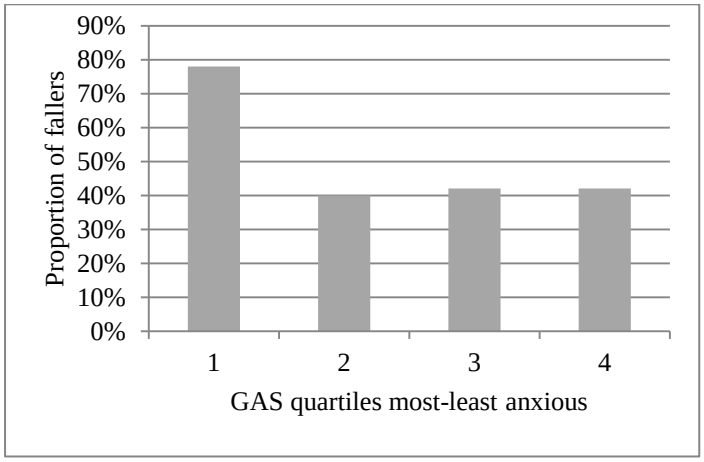
Figure 4.5 Thresholds for increased falls in Barthel, ACE-R and GAS



Barthel scores per quartile. 1 <45, 2= 46-70, 3= 71-85, 4 >85

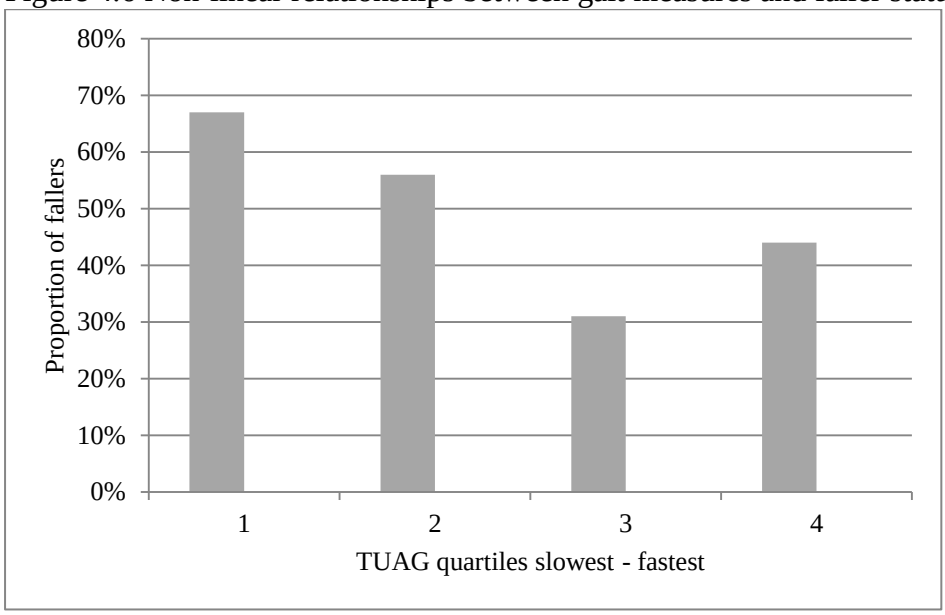


ACE-R scores per quartile. 1 <23, 2= 24-42, 3= 43-55, 4 >55

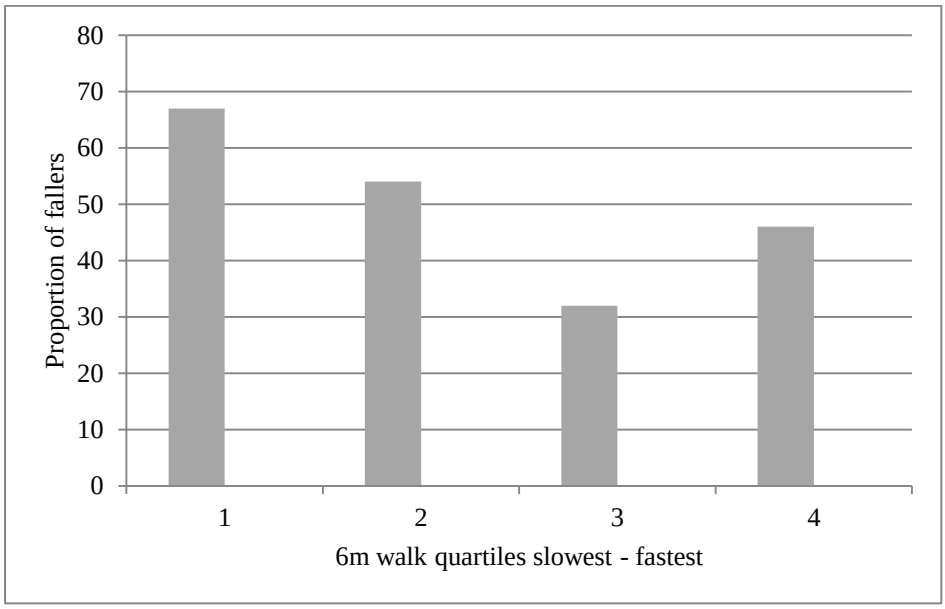


GAS scores per quartile. 1>4, 2=1-4, 3 and 4 = 0

Figure 4.6 Non-linear relationships between gait measures and faller status



TUAG (seconds) per quartile. 1 >118, 2= 118-47, 3= 46-20, 4 <19



6m Walk (seconds) per quartile. 1 >57, 2= 57-20, 3= 19-10, 4 <9

Categorical data

There were no significant differences (Chi square value=9.98 df=9, p=0.36) in the proportion of fallers in each care home with proportions ranging from 20-80% (mean 45%). No significant differences were identified between faller status and different diagnoses of cognitive impairment.

Dichotomous data

When analysing individual medical conditions (conditions affecting ≥10% of the sample), only hypertension was more prevalent in fallers compared to non-fallers (Table 4.27).

Table 4.27 Difference in the prevalence of medical conditions between fallers and non-fallers

	N-faller N (%) =56	**Faller N (%) =53**	**RR (95%CI)**
Diabetes	9 (16)	12 (23)	1.25 (0.73-2.12)
Thyroid dysfunction	6 (11)	10 (19)	1.43 (0.74-2.77)
Depression	8 (14)	12 (23)	1.35 (0.76-2.38)
Cataracts	8 (14)	12 (23)	1.35 (0.76-2.38)
Hypertension	17 (30)	27 (51)	1.55 (1.02-2.37)
Atrial fibrillation	5 (9)	6 (11)	1.15 (0.58-2.25)
CVA	9 (16)	14 (26)	1.40 (0.50-1.11)
Arthritis	22 (39)	30 (57)	1.41 (0.96-2.07)
Osteoporosis	5 (9)	8 (15)	1.38 (0.68-2.82)
Hip #	7 (13)	4 (8)	0.79 (0.48-1.28)

Examining individual drug groups (taken by ≥10% of the sample), fallers took more serotonin reuptake inhibitors (SSRIs) (Table 4.28).

Table 4.28 Medication use and association with faller status

	N-faller N (%) =56	**Faller N (%) =53**	**RR (95%CI)**
Proton pump inhibitors	17 (30)	24 (45)	1.38 (0.91-2.10)
Stimulant laxatives	12 (24)	18 (34)	1.39 (0.86-2.25)
Osmotic laxatives	18 (32)	16 (30)	0.96 (0.65-1.41)
Thiazides	7 (13)	8 (15)	1.12 (0.63-1.98)
Loop diuretics	13 (23)	6 (15)	0.79 (0.53-1.18)
Beta-adrenoceptor blocking drugs	4 (7)	7 (13)	1.46 (0.65-3.26)
ACE inhibitors	15 (27)	10 (15)	0.81 (0.55-1.20)
Calcium channel blockers	15 (27)	9 (17)	0.77 (0.53-1.13)
Anti-platelet drugs	24 (43)	30 (57)	1.31 (0.90-1.90)
Lipid regulating drugs	19 (34)	23 (43)	1.22 (0.82-1.82)
Anti-psychotic drugs	9 (16)	8 (15)	0.97 (0.59-1.58)
SSRIs	3 (5)	14 (26)	3.26 (1.15-9.25)
Non opioid analgesia	26 (46)	23 (43)	0.94 (0.65-1.36)
Sulphonylureas	4 (7)	7 (13)	1.46 (0.65-3.26)
Thyroid hormones	5 (9)	7 (13)	1.26 (0.63-2.55)
Bisphosponates	10 (18)	14 (26)	1.30 (0.78-1.19)
Oral iron	6 (11)	11 (21)	1.54 (0.79-3.01)
Drugs for hypoplastic, haemolytic and renal anaemias	7 (13)	7 (13)	1.03 (0.59-1.80)
Vitamin B	8 (14)	3 (6)	0.67 (0.45-1.02)
Calcium and vitamin D	16 (29)	21 (40)	1.29 (0.84-1.96)
Emollients	9 (16)	13 (26)	1.32 (0.77-2.26)

When drugs were grouped into larger classes and less prevalent groups known to increase falls risk examined, fallers took more antidepressants (see Table 4.29).

Table 4.29 Medication classes and groups associated with faller status

	N-faller N (%) =56	**Faller N (%) =53**	**RR (95%CI)**
GI drugs (any)	34 (61)	38 (72)	1.26 (0.88-1.81)
Cardiovascular drugs (excl lipid)	34 (61)	32 (60)	0.99 (0.68-1.44)
Cardiovascular drugs excl lipid and antiplatelet)	15 (27)	12 (23)	0.90 (0.60-1.34)
Antihypertensive drugs (any)	24 (43)	23 (43)	1.01 (0.70-1.46)
ACE inhibitors and AR blockers	18 (32)	11 (21)	0.77 (0.53-1.10)
Respiratory drugs (any)	8 (14)	6 (11)	0.88 (0.54-1.45)
CNS drugs (any)	37 (66)	39 (74)	1.18 (0.82-1.72)
CNS drugs (excl analgesia)	19 (34)	28 (53)	1.48 (0.99-2.21)
Hypnotics/anxiolytics	2 (4)	6 (11)	2.14 (0.64-7.20)
Antidpressants	8 (14)	20 (38)	2.07 (1.12-3.83)
Non-opioid analgesia and NSAIDS	27 (48)	24 (45)	0.94 (0.66-1.36)
Drugs for infection (any)	3 (5)	4 (8)	1.21 (0.51-2.91)
Drugs for diabetes (any)	6 (11)	9 (17)	1.33 (0.70-2.54)
Drugs for thyroid (any)	6 (11)	7 (13)	1.13 (0.61-2.08)
Musculoskeletal drugs (any)	4 (7)	6 (11)	1.31 (0.60-2.87)
Drugs or eyes (any)	4 (7)	8 (15)	1.61 (0.71-3.66)

Of the remaining dichotomous data, fallers were more likely to have fallen in the previous year than non-fallers. There were no significant differences in ethnicity and the prevalence of requiring nursing care or urinary incontinence (Table 4.30).

Table 4.30 Difference between fallers and non-fallers in dichotomous data

	Non -faller N (%) =56	Faller N (%) =53	RR (95%CI)
Female	33 (59)	36 (68)	1.20 (0.84-1.73)
Caucasian	48 (86)	48 (91)	1.23 (0.77-1.98)
Fall in the last year	40 (71)	49 (93)	1.78 (1.30-2.45)
Requires nursing care	4 (7)	0 (0)	0.50 (0.41-0.60)
Frame user	16 (29)	23 (43)	1.39 (0.91-2.14)
Wanderer	10 (18)	13 (26)	1.23 (0.74-2.04)
Urinary incontinence	25 (45)	22 (42)	0.94 (0.65-1.36)
Classical orthostatic hypotension	7 (13)	9 (17)	1.20 (0.67-2.17)
UL musculoskeletal abnormalities	8 (16)	15 (35)	1.71 (0.95-3.09)
LL musculoskeletal abnormalities	15 (31)	8 (19)	0.76 (0.52-1.11)
Neurological abnormalities	16 (33)	12 (28)	0.90 (0.61-1.35)
Stops on SWWT test	12 (21)	14 (26)	1.15 (0.72-1.82)

Continuous data dichotomised using the Youden index within the demographic and medical domain identified that those aged >82, taking >5 medications or having fallen in the past year were significantly more likely to fall. Most of the dichotomised sensori-motor, balance and gait measures were significantly associated with falls with the exception of vision, muscle strength and proprioception. Anxiety, impulsivity and scoring >21 on the NPI were significantly associated with likelihood of falling and the only neuropsychological measure that differed between fallers and non-fallers was the ACE-R, the sections of which were worse in fallers were attention and orientation, memory and verbal fluency (Table 4.31).

Table 4.31 Dichotomised continuous data

Measure	Cut point	Non-fallers (n=56) N (%)	Fallers (n=53) N (%)	RR (95%CI)
DEMOGRAPHIC AND MEDICAL				
Female	Yes	33 (59)	36 (68)	1.20 (0.84-1.73)
Age	>82	31 (55)	40 (76)	1.51 (1.06-2.14)
↓ systolic BP on standing	≥20mmHg	7 (13)	9 (17)	1.20 (0.67-2.17)
No of medications	>5	29 (52)	41 (77)	1.67 (1.18-2.37)
Environment score	<3	26 (55)	28 (64)	1.18 (0.79-1.75)
SENSORI-MOTOR, GAIT AND BALANCE				
Timed up and go	>48 secs	20 (36)	33 (62)	1.70 (1.15-2.53)
6 metre walk	>16 secs	24 (43)	36 (68)	1.63 (1.13-2.37)
Sit to stand score	<4	34 (61)	41 (77)	1.43 (1.01-2.03)
5X STS time	>32 secs	35 (63)	43 (81)	1.51 (1.07-2.13)
PPA score	>4.3	39 (70)	45 (85)	1.47 (1.03-2.09)
Melbourne edge test	<9	8 (14)	8 (15)	1.03 (0.61-1.75)
Knee extension strength	<13	29 (52)	36 (68)	1.38 (0.96-1.97)
Proprioception	>5	16 (29)	21 (40)	1.29 (0.84-1.96)
Grip strength	<24	48 (86)	50 (94)	1.49 (0.98-2.25)
Sway floor eyes open	>10955mm	22 (39)	34 (64)	1.63 (1.11-2.39)
Sway floor eyes closed	>4500mm	12 (21)	27 (51)	2.04 (1.23-3.38)
Sway foam eyes open	>10040mm	31 (55)	42 (79)	1.64 (1.16-2.31)
Total balance score	<1.9	21 (38)	33 (62)	1.64 (1.11-2.42)
BEHAVIOURAL AND PSYCHIATRIC SYMPTOMS				
Impulsivity/wandering	>4	17 (30)	33 (62)	1.94 (1.27-2.98)
Goldberg Anxiety Scale	>4	4 (7)	18 (34)	3.29 (1.33-8.10)
Geriatric depression scale	>5	19 (35)	26 (49)	1.34 (0.89-2.01)
Neuropsychiatric inventory	>21	9 (16)	23 (43)	2.17 (1.21-3.88)
NEUROPSYCHOLOGICAL				
ACE-R	<40	19 (34)	34 (64)	1.84 (1.23-2.77)
Attention and orientation	<9	18 (32)	35 (66)	2.00 (1.32-3.03)
Memory	<7	24(43)	37 (70)	1.69 (1.17-2.45)
Fluency	<3	24 (43)	37 (70)	1.69 (1.17-2.45)
Language	<19	41 (73)	45 (85)	1.37 (0.94-1.98)
Visuospatial	<7	20 (36)	28 (53)	1.42 (0.95-2.10)
WMS-III Logical memory story	<6	45 (80)	43 (81)	1.02 (0.65-1.62)
WMS-III LMS delayed	<1	32 (57)	32 (60)	1.07 (0.74-1.54)
Boston naming test	<5	32 (57)	27 (51)	0.89 (0.61-1.28)
Hand reaction time	>453msecs	16 (29)	23 (43)	1.39 (0.91-2.14)
Trail making test A	>101secs	46 (82)	49 (93)	1.48 (0.99-2.18)

4.3.1.6.2 Logistic regression

Continuous and dichotomous variables were entered into logistic regression analysis for each domain separately and the independent and significant risk factors identified for each domain are listed in Table 4.32.

Table 4.32 Details of independent and significant variables identified with logistic regression analysis within each domain

Variable	B	Wald	Sig	OR (95%CI)
Medical and demographic				
No of medical conditions	0.45	5.57	0.02	1.57 (1.08-2.29)
Antidepressants	1.23	4.85	0.03	3.41 (1.14-10.17)
Sensori-motor, balance and gait				
Sway eyes closed	0.00	9.49	0.002	1.00 (1.00-1.00)
Behavioural and psychiatric symptoms				
GAS	0.25	8.06	0.005	1.28 (1.08-1.52)
Neuropsychological				
ACE-R	-0.02	5.07	0.024	0.97 (0.96-1.00)
If domains of ACE-R included				
Attention and Orientation	-0.10	6.03	0.01	0.91 (0.84-0.98)

[1] Conditions summed if present = stroke, hypertension, diabetes, arthritis, Parkinson's disease, previous hip fracture and depression

Five variables; number of medical conditions, antidepressant use, sway with eyes closed, GAS and attention and orientation (from the ACE-R) were then entered into logistic regression analysis which identified 4 significant independent risk factors; use of antidepressants, sway with eyes closed, GAS and attention and orientation (Table 4.33). This was named model A.

Table 4.33 Model A. Significant and independent variables on logistic regression analysis

Variable	B	Wald	Sig	OR (95%CI)
Antidepressants	1.38	6.58	0.01	3.96 (1.38-11.36)
Sway eyes closed	0.00	8.86	0.003	1.00 (1.00-1.00)
GAS	0.24	5.91	0.02	1.27 (1.05-1.55)
Attention and Orientation	-0.10	4.62	0.03	0.91 (0.83-0.99)

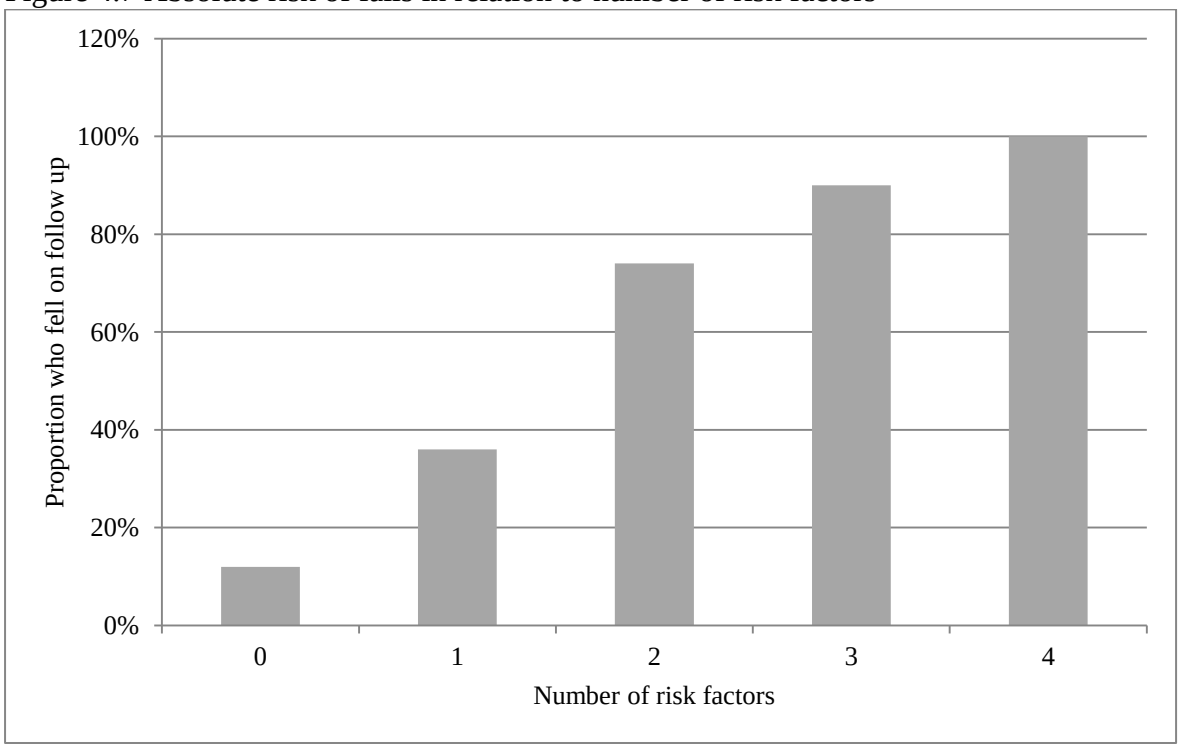
To simplify interpretation of clinical data, the dichotomised continuous data (used in model A) were entered into logistic regression analysis, all remained independently significant and this was named model B (Table 4.34).

Table 4.34 Model B. Significant and independent variables on logistic regression using dichotomised data.

Variable	Cut point	B	Wald	Sig	OR (95%CI)
Antidepressants	Yes	1.20	4.56	0.03	3.32 (1.10-9.97)
Sway eyes closed	>4500	1.42	7.38	0.007	4.15 (1.49-11.57)
GAS	>4	2.31	10.15	0.001	10.04 (2.43-41.50)
Attention and Orientation	<9	2.05	14.69	<0.001	7.74 (2.71-22.06)

The AUC for model A was 0.80 (95% CI 0.71-0.88) and model B was 0.84 (95% CI 0.76–0.91). Figure 4.7 presents the proportion of fallers with 0-4 of the risk factors using model B. Twelve percent of those with no risk factors fell in the 6 month follow up rising to 100% of those with 4 of these risk factors.

Figure 4.7 Absolute risk of falls in relation to number of risk factors



Legend: Risk factors identified from the logistic regression analysis: taking antidepressants, sway >4500mm when standing with eyes closed, scored <9 in attention and orientation domain of the ACE-R and score >4 on the Goldberg anxiety scale.

4.3.1.7 Fall rates

4.3.1.7.1 Univariate analysis

Falls rates were significantly higher in those who took >5 medications. Those who took longer than 48 seconds on the timed up and go or 16 seconds on the 6 metre walk, those with a PPA score of >4.3 and total balance score of <1.9 had significantly more falls. More falls were also associated with an impulsivity score of >4 and ACE-R <40. Domains of the ACE-R associated with higher falls rates were attention and orientation (score <9) and memory (score <7) (Table 4.35).

Table 4.35 Incident rate ratios for falls for each variable (adjusted for follow-up time)

Variable	Cut point	IRR (falls) (95%CI)
DEMOGRAPHIC AND MEDICAL		
Female	Yes	0.99 (0.53-0.87)
Age	>82	1.82 (0.95-3.45)
Fall in previous year	Yes	2.14 (0.94-4.91)
Walking frame user	Yes	1.45 (0.77-2.73)
Urinary incontinence	Yes	1.43 (0.78-2.63)
Medical conditions	>2	1.28 (0.64-2.56)
Barthel	<65	1.71 (0.93-3.15)
↓ systolic BP on standing	≥20mmHg	1.01 (0.43-2.37)
CNS medication	Any	1.48 (0.80-2.71)
Anti-depressant	Any	1.82 (0.93-3.57)
Hypnotic/anxiolytic	Any	1.43 (0.47-4.41)
ACE-Is and ARBs	Any	0.95 (0.48-1.90)
Anti-platelet	Any	1.47 (0.80-2.70)
NSAIDS/non opioid analgesia	Any	1.14 (0.61-2.10)
Anti-hypertensives	Any	1.19 (0.64-2.21)
Opioid analgesia	Any	1.08 (0.36-3.25)
Anti-psychotics	Any	0.87 (0.37-2.01)
No of medications	>5	2.01(1.11-3.97)
Environment score	<3	1.04 (0.53-2.04)
SENSORI-MOTOR, GAIT AND BALANCE		
Timed up and go	>48 secs	1.91 (1.05-3.48)
6 metre walk	>16 secs	1.83 (1.00-3.36)
Sit to stand score	<4	1.41 (0.72-2.77)
5X STS time	>32 secs	1.84 (0.93-3.67)
PPA score	>4.3	2.30 (1.08-4.90)
Melbourne edge test	<9	1.06 (0.45-2.52)
Knee extension strength	<13	1.67 (0.90-3.10)
Proprioception	>5	1.25 (0.66-2.39)
Grip strength	<24	0.80 (0.30-2.14)

Variable	Cut point	IRR (falls) (95%CI)
Sway floor eyes open	>10955mm	1.09 (0.59-2.02)
Sway floor eyes closed	>4545mm	1.75 (0.94-3.23)
Sway foam eyes open	>10040mm	1.71 (0.88-3.33)
Total balance score	<1.9	1.84 (1.01-3.35)
BEHAVIOURAL AND PSYCHIATRIC SYMPTOMS		
Impulsivity/wandering	≥4	1.89 (1.04-3.43)
Goldberg Anxiety Scale	>2	1.67 (0.84-3.30)
Geriatric depression scale	>5	1.05 (0.57-1.94)
Neuropsychiatric inventory	>21	1.78 (0.93-3.40)
NEUROPSYCHOLOGICAL		
ACE-R	<40	1.96 (1.10-3.50)
Attention and orientation	<9	2.20 (1.23-3.91)
Memory	<7	1.99 (1.10-3.60)
Fluency	<3	1.66 (0.91-3.00)
Language	<19	1.47 (0.70-3.12)
Visuospatial	<7	1.48 (0.82-2.67)
WMS-III Logical memory story	<6	0.98 (0.45-2.10)
WMS-III LMS delayed	<1	0.94 (0.51-1.74)
Boston naming test	<5	1.26 (0.68-2.32)
Hand reaction time	>453msecs	1.45 (0.77-2.72)
Stops walking when talking	Yes	1.54 (0.76-3.13)
Trail making test A	>101secs	2.04 (0.78-5.32)

4.3.1.7.2 Multivariate analysis

Multivariate negative binomial regression analysis identified attention and orientation score <9, IRR=1.77 (95%CI 1.13-3.42), PPA falls risk score >4.3, IRR=2.21 (95%CI 1.01-4.80) and NPI >21, IRR=1.94 (95%CI 1.10-3.41) to be independently associated with falls risk. Taking >5 medications just missed also contributing to this model, IRR=1.77 (95%CI 0.97-3.21).

4.4 Discussion

In this study, a number of variables were significantly different between the fallers and non-fallers in univariate analyses. The final explanatory model included variables from each of these domains: antidepressant use, increased postural sway with eyes closed, anxiety and poor attention and orientation and confirms the multi-factorial nature of the fall risk in this population.

A number of these risk factors have been identified in previous studies. Impaired balance is a consistent fall risk factor in all populations including those in residential care (Robbins et al., 1989, Thapa et al., 1996b). In this study, unlike others, there was a linear relationship between balance function and falls (Lord et al., 2003a). The two measures of mobility / gait (6 metre walk and timed up and go) did appear to demonstrate a non-linear pattern where those with the best and worst function fell the most. Although it was not enough to prevent both measures discriminating between fallers and non-fallers when dichotomised using the Youden index (Table 4.31). Interestingly, there was a trend for those in the fastest quartiles for both 6m walk and timed up and go to have worse cognition measured with the ACE-R than those in the second fastest quartiles. This could mean that those with worse cognition are failing to adopt a conservative gait pattern (described on page 35), however this was not supported in the fact that those in the fastest quartiles had better balance scores (Table 4.36).

Table 4.36 Difference in cognition and balance between 1st and 2nd quartiles for gait measures

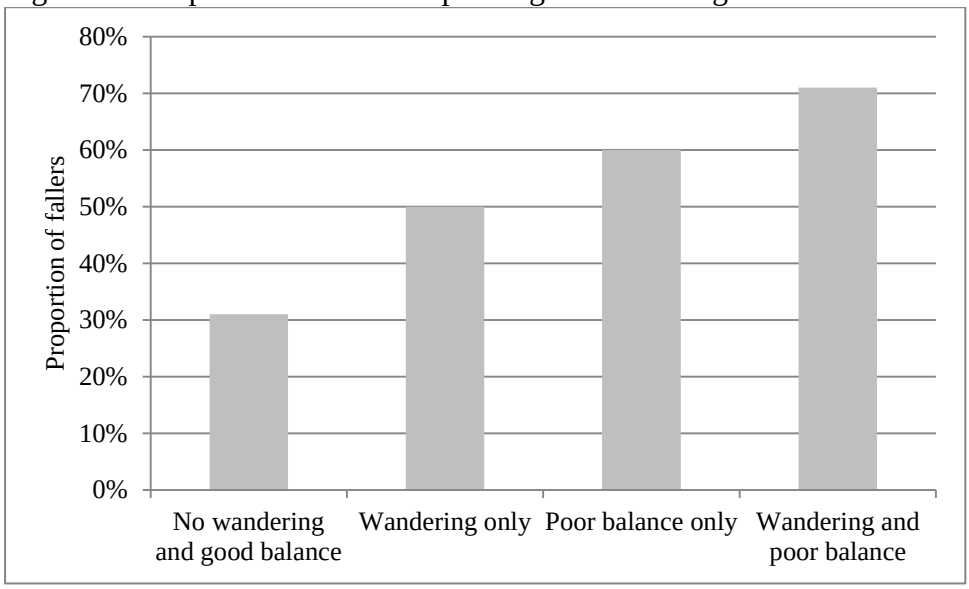
	Mean score quartile 1 (SD)	**Mean score quartile 2 (SD)**	**P**
6 metre walk	**<9 seconds**	**10-20 seconds**	
ACE-R	40 (16)	46 (22)	0.3
Balance score	2.9 (0.7)	2.5 (0.9)	0.1
Timed up and go	**<19 seconds**	**20-46 seconds**	
ACE-R	39 (18)	48 (18)	0.06
Balance score	2.9 (0.9)	2.3 (0.8)	0.005

Other work in residential care has identified impaired cognition as a fall risk factor (van Dijk et al., 1993, van Doorn et al., 2003) and this study supports existing strong evidence for the effect of psychotropic medications, in particular antidepressants, on fall risk (Thapa et al., 1995, Thapa et al., 1998, Sterke et al., 2012b) Although fear of falls, which is associated with anxiety has been commonly associated with falls, measures of anxiety have not featured in many risk factor studies. One study however, found that anxiety was the most common symptom preceding a fall in nursing home residents (Pellfolk et al., 2009).

The fallers and non-fallers did not differ with respect to vision, proprioception or knee extension strength. However, fallers performed significantly worse in the tests of balance and gait, most notably in the tests of postural sway. This pattern of findings suggests that the decreased postural stability in the fallers may relate to central neuro-pathological processes associated with cognitive impairment and dementia and likely disruptions to the central integration of neural networks that are essential for the maintenance of an upright posture (Shumway-Cook and Woollacott, 1995). It is also possible that medications affecting the central nervous system had an impact on fall risk by directly affecting balance control (Lord et al., 1992).

Many variables within the behaviour and affect domain were significantly associated with falls. Wandering may increase the risk of falls by increasing exposure due to more time spent standing and walking. In this sample, fall risk was indeed higher in those who exhibited wandering and had poor standing balance (using the cut point identified using the Youden index) demonstrated in Figure 4.8.

Figure 4.8 Proportion of fallers depending on wandering and balance status



The GAS measure of anxiety was strongly associated with risk of falls. Anxiety can impede postural responses to perturbations (Adkin et al., 2002) and therefore may directly increase fall risk through postural instability. The current study found no correlation between balance and GAS scores ($r=-0.1$, $p=0.3$) suggesting this did not fully explain the findings. Anxiety may also relate to the underlying pathology and neuro-chemical changes associated with dementias (Ballard et al., 1996) and it is also possible that the GAS, which includes words such as “on edge”, “irritable” and “trembling”, may actually be a measure of agitation in this population. GAS scores were significantly correlated with total NPI scores ($r=0.35$, $p<0.001$) as well as being correlated to the individual questions around irritability ($r=0.47$, $p<0.001$), anxiety ($r=0.39$, $p<0.001$), depression ($r=0.31$, $p=0.001$) and apathy ($r= 0.22$, $p=0.02$) but not agitation ($r=0.04$, $p=0.7$).

Depressive symptomatology as measured using the GDS was not associated with falls, but the use of antidepressants was identified as an independent predictor of falls. These two factors, which have both been previously shown to be associated with fall risk are

intrinsically linked, making the mechanisms by which they increase risk unclear (Nevitt et al., 1989, Lord et al., 1995). It is also possible that the GDS is not an ideal tool for assessing depressive symptoms in people with marked cognitive impairment.

The effect of psychotropic medications on gait and balance is well established (Thapa et al., 1995) as is the potential to reduce falls through careful reduction and minimisation of CNS medication use (Zermansky et al., 2006). With respect to the use of other medications, residents taking cardiovascular medications were not more likely to fall, but residents who took more than five medications, a likely marker of ill health, were.

The ACE-R, when used as a global measure of cognition, was able to differentiate between fallers and non-fallers in the univariate analysis but in the logistic regression model the attention and orientation section was independently associated with increased risk of falls. Many of the other neuropsychological tests undertaken failed to differentiate between fallers and non-fallers and it is possible that this relates to the floor effects of the tests given in that many were either unable to perform the test or scored very poorly. Deficits in attention and orientation include difficulty concentrating which may be associated with impulsive behaviour. This is discussed in chapter 6. Impaired memory may increase fall risk from failure to recall previously learnt safety strategies including remembering to use an assistive device.

This study was undertaken to develop an explanatory model for falls with the ultimate objective of guiding future targeted intervention programs to prevent falls in this population. The identified factors in the final model are potentially amenable to or need to be considered when designing any approach to intervention. This will be covered in the discussion chapter.

4.4.1 Limitations

This study has certain limitations. Firstly, 54 residents were not assessed as they were incapable of completing the in-depth assessments. The findings reported here may therefore not be applicable for people with severe dementia in residential care. Secondly, although the study involved seven care homes and recruited one of the largest samples for a study into fall risk in participants with cognitive impairment, the study findings will need confirming in another sample.

4.4.2 Conclusion

This study identifies important risk factors for falls which are potentially amenable to intervention in older people with cognitive impairment living in a residential care setting. This information will provide direction for fall prevention strategies for this group.

Defining Falls Risk Factors in Older Adults with Cognitive Impairment Living in Residential Care

Chapter 5

Development of a scale of physical activity and mobility in residential care (PAM-RC)

5 Development of a scale of physical activity and mobility in residential care (PAM-RC)

5.1 Introduction

Higher levels of physical activity have been found to protect against falls (Heesch et al., 2008) but also present more opportunity to fall and there is a genuine risk that physical activity interventions may increase fall rates, particularly in frail older people. Prospective fall risk factor studies in residential care have found that those with the best and the worst physical function fall less frequently than those with intermediate functional ability (Thapa et al., 1996a, Lord et al., 2003a). It is possible that these non-linear patterns are partly explained through differing activity levels and exposure to risk.

It is important to measure physical activity levels for two reasons. Firstly to understand the role of physical activity in fall risk and secondly to examine how preventative interventions affect activity levels in the context of fall rates.

Several scales have been devised to measure physical activity in community dwelling older people (Stewart et al., 2001, Young et al., 2001, Washburn et al., 1993) which have been validated against activity levels measured with body fixed activity monitors (Harada et al., 2001). Despite this, the Prevention of Falls Network Europe consensus in 2005 concluded that none of these scales were sufficient to use in fall prevention intervention trials primarily due to their focus on moderate to high levels of physical activity and failure to address low intensity physical activities (Jorstad-Stein et al., 2005). The Incidental and Planned Exercise Questionnaire for older people (IPEQ) (Delbaere et al., 2010b) and the Assessment of

Physical Activity in Frail Older People (APAFOP) (Hauer et al., 2011) were developed in response to this.

These newer scales more accurately capture low level physical activity, but have limitations for use with frail older people with memory problems as they require adequate recall of recent daily activity. Further, many residential care dwellers do not take part in structured activities that form a large component of current scales and most have limited ability to undertake activities of daily living independently. Therefore a different approach is required to determine physical activity levels in this group. This paper describes the development and validation of the Physical Activity and Mobility in Residential Care (PAM-RC) scale designed to be completed by a resident's key carer and suitable for use in residential care.

5.2 Methods

5.2.1.1 Participants

Data were collected from participants of the detailed data collection study (chapter 4). Informed consent for participation in the study was obtained from the participants or from legal carers. The South London and Maudsley and Institute of Psychiatry joint ethics committee approved the study. Participants for this sub-study were selected if they agreed to wear an activity monitor and did not exhibit behaviours such as losing/hiding objects, based on care staff reports. Participants who completed at least 24 hours continuous measurement with activity monitors within 2 weeks of having a completed PAM-RC were included in this study.

5.2.1.2 The PAM-RC scale

The scale was designed to be completed by residents' key carers and based on physical activity levels over the previous week. An initial version was drafted by the research team and this was then evaluated by five carers to improve face and content validity. The scale was then revised and piloted on 10 residents leading to further revisions. After completing data collection, one question regarding participation in organised activities was excluded as it was not related to any of the other questions or measures used and reduced the internal reliability (Chronbach's α) of the scale. The final version of the PAM-RC scale is shown in Figure 5.1.

The PAM-RC questions addressed activity levels, wandering, outdoor mobility, balance and gait. The two questions on mobility and balance ability were included as it was considered that independence in mobility in those living in residential care was likely to significantly influence activity levels. Those requiring help would have to wait for it to be successfully active whereas independence would mean mobilisation could occur at any time. The most common physical activity (with the exception of sitting or lying) in this group was likely to be walking, whether it was purposeful or non-purposeful (wandering). It was possible to rate whether purposeful walking occurred not at all, in only minimal amounts (i.e. to an en-suite facility from a bed), only when asked to walk (i.e. to go to the dining room) or more often than when asked to. Non-purposeful walking could be measured by rating the severity of wandering behaviours. The exact time spent on specific activities was not recorded as it was not feasible to question every carer that had contact with a resident over a one week period. The total PAM-RC score was calculated by summing the scores for each question (each graded between 0-3 and 0-6). The PAM-RC scale was re-administered to the same carers 1

week after initial assessment for a randomly selected sub-set of 30 residents (70% of final sample) to evaluate test-retest reliability.

Figure 5.1 The PAM-RC questionnaire

ABILITY

Mobility

Bedbound	0
Wheelchair bound (transfers with hoist)	1
Wheelchair bound (standing transfers with assistance)	2
Wheelchair bound (standing transfers without assistance)	3
Able to walk short distances within room (<3m) with / without aids / assistance	4
Walks longer distances (>3m) using walking aid / assistance / supervision	5
Walks longer distances (>3m) independently	6

Balance

Immobile	0
Needs assistance of one or two people to maintain balance	1
Needs to use walking aid (stick/frame) to maintain balance	2
Uses no walking aid but unsteady	3
Uses no walking aid but gait is steady	4

ACTIVITY

Walking frequency

Doesn't walk at all	0
Walks in room to help with personal care (i.e to the toilet or commode)	1
Walks in the room and around the home only when necessary (toilet / dining area)	2
Walks around home more often than for necessary functions but spends majority of time sitting	3
Walks around the home more often than for necessary functions spending only short times sitting	4

Wandering

Wandering not exhibited in last 7 days	0
Wandering occurred 1-3 days out of last 7	1
Wandering occurred 4-6 days out of last 7	2
Wandering occurred daily	3

Outdoor mobility

Doesn't go out (except for hospital appointments)	0
Only goes out in wheelchair	1
Goes for short walks <50m with assistance of carer (i.e. around the garden)	2
Goes for longer walks >50m with assistance of carer (i.e. to local shops)	3
Goes out longer distances >50m without carers (?includes absconding)	4

5.2.1.3 Measurement of physical activity with activity monitors

An ActivPal™ activity monitor (53 x 35 x 7 mm) was attached to the participant's anterior thigh. Sit to stand frequency, time spent lying or sitting, time spent standing and number of steps taken were measured continuously with this monitor for up to three days. This is described in more detail in chapter 2.

5.2.1.4 Cognitive, balance, gait and mobility measures

Function, sensori-motor, gait and balance, behavioural and psychiatric symptoms, neuropsychological function and falls were measured using methods described in chapter 2.

5.2.1.5 Statistical analysis

The internal reliability for the PAM-RC scale was assessed by calculating the Cronbach's α for the whole scale, by checking whether exclusion of each item increased the Cronbach's α coefficient and by examining Spearman's correlations between items. The structure for the scale was evaluated using a principal components analysis with Varimax rotation and selection of factors based on eigenvalues of >1. Test-retest reliability of the PAM-RC scale was assessed with analysis of differences in the means using t tests and 95% confidence intervals of the mean difference, variability of the data was presented as SEM and %SEM and the correlation between the first and second measure analysed using intra-class correlation coefficients. Test-retest reliability was not feasible for the activity monitors but reliability between days of collection was analysed using intraclass correlation coefficients (2,1).

Time spent sitting/lying was the primary measurement used to determine the construct validity of the PAM-RC scale. This measure was chosen as previous work has found that step counts can be underestimated in those with slow walking speeds or reduced foot clearance

(Cyarto et al., 2004). PAM-RC total scores and ability and activity sub-scale scores were tested for correlations with sitting/lying time, other measures of activity collected using the ActivPal sensor and sensorimotor, balance, behavioural and neuropsychological measures using Spearman rho. The PAM-RC total score was dichotomised by calculating the optimal specificity and sensitivity for falls using the Youden index (Ruopp et al., 2008). A relative risk statistic was then calculated to examine whether low activity levels were a risk factor for falls. Analyses were performed using SPSS for Windows (Version 19, SPSS, Inc., Chicago, IL, USA).

5.3 Results

From 116 potential participants from seven residential care homes, 43 either refused to wear a monitor or were judged likely to lose/hide it. Of the remaining 73 participants, an activity monitor was not available for 26 participants, leaving 47 participants who agreed to use the monitor and for which data collection was attempted. Those who were monitored were generally less physically and cognitively frail evidenced by significantly better grip strength and ACE-R scores (Table 5.1). T tests revealed no significant differences between those who wore a monitor and those who did not have a monitor available. T tests between those who had the monitor applied and those who refused or were likely to lose it demonstrated that those who refused had significantly worse cognition (t= -3.3 ^{df}88 P=0.001). There were no differences in other measures.

Table 5.1 Differences between those who were monitored and those who were not

Variable	Monitor not available N=26 Mean (SD)	Monitor not used (refused or deemed likely to lose) N=43 Mean (SD)	Monitor applied N=47 Mean (SD)
Age	84.4 (8.3)	83.8 (9.0)	84.5 (7.8)
Barthel (0-100)	64.0 (28.6)	56.7 (25.6)	67.2 (22.4)
Grip strength (Kgs)[a]	8.2 (3.7)	10.6 (7.9)	13.4 (7.5)
Timed up and go (secs)	85.4 (64.3)	97.5 (84.0)	60.1 (66.6)
6 metre walk (secs)	42.2 (34.0)	49.3 (47.6)	30.0 (34.7)
Balance score (0-5)	1.45 (1.20)	1.43 (1.10)	2.00 (1.37)
GAS (0-9)	2.0 (1.6)	2.0 (2.2)	2.1 (2.6)
GDS (0-15)	5.4 (2.5)	5.4 (3.2)	4.7 (3.3)
NPI (0-144)	16.6 (21.4)	18.0 (18.1)	13.3 (12.8)
ACE-R (0-100)[b]	39.9 (25.4)	39.6 (19.2)	50.8 (22.5)
	N (%)	N (%)	N (%)
Sex =female	16 (62)	27 (63)	30 (64)
Fall in 6/12 follow up	12 (46)	25 (58)	22 (47)

[a]= Between group differences on one way ANOVA, p=0.008
[b]= Between group differences on one way ANOVA, p=0.03

Nine participants removed their monitors during the measurement period. Five of the monitors were recovered and each had recorded at least 24 hours activity data. Three of the remaining four participants lost their monitors, which were never recovered. Therefore, data from 43 participants, were available for analysis.

5.3.1.1 PAM-RC

The median PAM-RC score for walking ability was 5, a score equivalent to being able to walk more than 3 metres with assistance or a walking aid. For balance the score was 2, indicating the need for a walking aid for balance. Walking frequency median score was 3 equating to walking more often than when asked but still spending most of the time sitting. The median score for wandering was 0 = not wandering and for outdoor mobility was 1 = only goes out in a wheelchair (Table 5.2).

Table 5.2 Details of PAM-RC scores

Question	Mean (SD)	Median	Range
Walking ability (0-6)	5.1 (1.2)	5	1-6
Balance ability (0-4)	2.7 (1.1)	2	0-4
Walking frequency (0-4)	2.7 (1.1)	3	0-4
Wandering frequency (0-3)	0.3 (0.9)	0	0-3
Outdoor mobility (0-4)	1.7 (1.5)	1	0-4
Total score (0-21)	12.6 (4.1)	13.5	1-19

5.3.1.2 Activity monitoring

The mean amount of activity monitor data collected was 66 hours (range 24-72 hours). Data was skewed (and not improved with log transformation) therefore, data was analysed using non-parametric methods. Residents spent a median of 22.1 hours lying or sitting down, 1.6 hours standing and 0.3 hours walking (Table 5.3).

Table 5.3 Activity monitor data for 24 hour period

24 hours	Mean (SD)	Skew	Median (interquartile range)	Range
Lying (hours)	21.7 (1.9)	-1.09	22.1 (20.8-23.1)	16.6-24.0
Standing (hours)	2.0 (1.8)	1.19	1.6 (0.7-2.7)	0.03-6.6
Walking (hours)	0.31 (0.17)	0.73	0.3 (0.05-0.49)	0-1.1
Sit to stands (no.)	42.1 (25.2)	0.75	37.0 (24.7-57.7)	3-106
Steps (no.)	1269 (1178)	0.75	1099 (133-2143)	0-4263

Intra class correlation coefficients revealed excellent reliability between activity on each day of monitoring. Standing and sit to stand had the highest ICCs and steps and walking to lowest (Table 5.4).

Table 5.4 Intra class correlation coefficients between measurement days

	ICC [2,1] (95%CI)
Lying	0.95 (0.91-0.97)
Standing	0.97 (0.94-0.98)
Walking	0.93 (0.88-0.96)
Sit to stands	0.97 (0.95-0.98)
Steps	0.92 (0.85-0.95)

5.3.1.3 Internal consistency and test-retest reliability

The Cronbach's α for the total PAM-RC was 0.76. The Cronbach's α for the ability and activity subcomponents were 0.89 and 0.42 respectively. See Table 5.5 for details of Chronbach's α with each question subtracted. The mean inter-item correlation was 0.36. The lowest inter-item correlation was between the balance and wandering questions (r=0.005) and the highest was between walking and balance ability r=0.91. Apart from these two highly correlated questions, the other questions did not suggest any concern with collinearity (Table 5.6).

Table 5.5 Chronbach's alpha

	Chronbach's α
Total PAM-RC score	0.76
Abilities subscore	0.89
Activities subscore	0.42
Excluding question 1	0.61
Excluding question 2	0.66
Excluding question 3	0.65
Excluding question 4	0.83
Excluding question 5	0.78

Table 5.6 Inter-item correlations between items on the PAM-RC

Question	**Walking ability**	**Balance**	**Walking frequency**	**Wandering**	**Outdoor mobility**
Walking ability		0.91**	0.56**	0.12	0.47*
Balance	0.91**		0.50*	0.005	0.41*
Walking frequency	0.56**	0.50*		0.40*	0.41*
Wandering	0.12	0.005	0.40*		-0.17
Outdoor mobility	0.47*	0.41*	0.41*	-0.17	

** P<0.001, *P<0.01

5.3.1.4 Test retest reliability

Table 5.7 Reliability data

Mean 1 (SD)	11.0 (4.9)
Mean 2 (SD)	10.4 (5.1)
Mean difference (95%CI)	-0.57 (-3.17-1.73)
T test (df)	2.48 (29)
Significance	0.02
SEM (%SEM)	0.88 (8%)
ICC (95%CI) [2,1]	0.98 (0.97-0.99)

The second PAM-RC score was slightly lower than the first. This reached statistical significance but the actual clinical difference was very small (<1 point on the scale). The scale had very little variability and the two measurements were very closely related with an intra-class correlation coefficient 0.98 (95%CI 0.97-0.99).

5.3.1.5 Factor analysis

Table 5.8 Rotated components extracted

Factor	**1**	**2**
Walking ability	0.91	0.14
Balance	0.87	0.00
Walking frequency	0.82	0.33
Wandering	0.10	0.94
Outdoor mobility	0.70	-0.41

Principal component analysis revealed two PAM-RC scale factors. Walking ability, walking frequency, balance and outdoor mobility contributed to the first factor accounting for 55% of the variance. Only the wandering item loaded to the second factor and accounted for 23% of the variance (Table 5.8).

5.3.1.6 Construct validity

As shown in Table 5.9 , PAM-RC total score was significantly inversely associated with time spent lying or sitting and positively correlated with number of sit to stands, number of steps, time standing and time walking as measured with the activity monitors. Correlations between activity monitor data were generally better for the activities questions compared to ability questions. The walking frequency question on its own was also closely related to the activity monitor data.

Table 5.9 Correlations between activity monitor measures and PAM-RC scores

	Total score	Abilities questions	Activities questions	Walking frequency question
Lying or sitting (hours)	-0.72[2]	-0.60[2]	-0.77[2]	-0.72[2]
Steps	0.74[2]	0.74[2]	0.67[2]	0.53[2]
Sit to stands	0.65[2]	0.59[2]	0.66[2]	0.52[2]
Standing (hours)	0.67[2]	0.55[2]	0.73[2]	0.67[2]
Walking (hours)	0.71[2]	0.70[2]	0.67[2]	0.53[2]

[2] p<0.001

In addition, PAM-RC total scores were significantly correlated with Barthel scores, grip strength, timed up and go, six metre walk and balance scores with the abilities questions being more highly correlated to these measures (Table 5.10).

Table 5.10 Correlations between the PAM-RC and demographic, mobility and cognitive measures

	Total score	Abilities questions	Activities questions	Walking frequency question
Age	-0.31[1]	-0.33[1]	-0.26	-0.15
ACE-R *	-0.09	-0.01	-0.04	-0.13
Barthel*	0.56[2]	0.64[2]	0.49[2]	0.44[1]
NPI#	0.00	-0.07	0.04	-0.04
Grip strength* (Kg)	0.34[1]	0.29	0.39[1]	0.37[1]
Timed up and go # (seconds)	-0.83[2]	-0.81[2]	-0.72[2]	-0.57[2]
6 metre walk #(seconds)	-0.85[2]	-0.83[2]	-0.74[2]	0.64[2]
Balance scale*	0.72[2]	-0.70[2]	0.64[2]	0.62[2]

[1] P<0.05
[2] p<0.001
* Higher score = better function
# Higher score = worse function

Activity monitor measures were correlated with measures of function (Barthel), gait and balance but not cognition or behaviour (Table 5.11).

Table 5.11 Correlations between activity monitor measures and demographic, mobility and cognitive measures

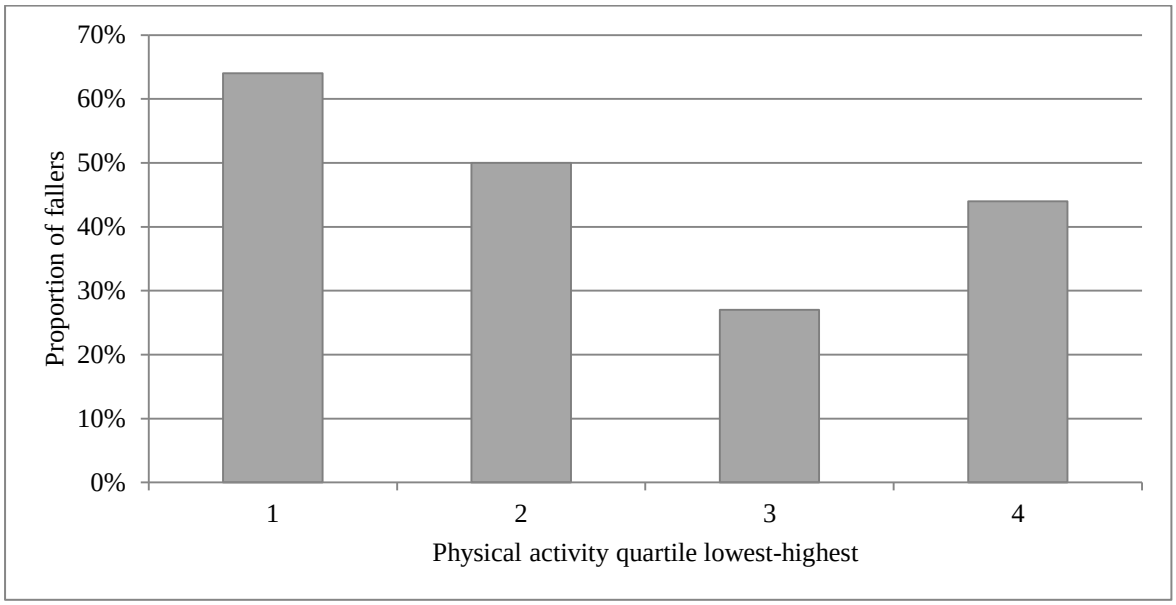
	Lying/sitting	Standing	Walking	Sit to stand	Steps
Age	0.19	-0.22	-0.13	-0.26	-0.17
ACE-R*	-0.78	0.12	-0.06	0.17	-0.02
Barthel*	-0.49[1]	0.48[1]	0.47[1]	0.48[1]	0.49[1]
NPI#	-0.06	0.03	0.17	-0.10	0.11
Grip strength*	-0.58[2]	0.53[2]	0.37[1]	0.36[1]	0.40[1]
Timed up and go#	0.60[2]	-0.54[2]	-0.74[2]	-0.68[2]	-0.77[2]
6 metre walk#	0.57[2]	-0.51[2]	-0.65[2]	-0.57[2]	-0.71[2]
Balance*	-0.51[2]	0.47[1]	0.55[2]	0.60[2]	0.57[2]

[1] P<0.05
[2] p<0.001
* Higher score = better function
# Higher score = worse function

5.3.1.7 Falls and physical activity

Twenty (47%) participants experienced 66 falls in the six months follow up. The optimal cut point for discriminating between those who did not fall and those who fell one or more times in this period on the PAM-RC scale was 14 , with participants scoring less than this, significantly more likely to fall; RR 1.81 (95%CI 1.03-3.16). While those in the lowest 2 quartiles of PAM-RC score fell more (64% and 50%), the proportion of falls then rose from 27% in the 3rd quartile to 44% in the highest quartile (Figure 5.2).

Figure 5.2 Proportion of fallers in lowest to highest quartiles of physical activity using the PAM-RC



When the PAM-RC score was entered into logistic regression analysis alongside other significant variables from chapter 4, it was not an independent predictor of falls. The odds ratio for a score <14 on the PAM-RC was 1.35 (0.49-3.73) when adjusted for antidepressant use, GAS score >4, attention and orientation score <9 and sway with eyes closed of >4500mm.

5.4 Discussion

The PAM-RC scale was highly correlated with physical activity measured using activity monitors and it had excellent test retest reliability. The scale had very good internal consistency and identified two components of physical activity in this population, purposeful and non-purposeful activity. The scale appears to have good construct validity covering all the aspects of physical activity that could be expected in a residential care setting. This validity was improved by consulting care staff during the development process (as described in the method).

The demographics of this population suggest for most of the participants, this method of measuring physical activity was more appropriate than previously developed scales. In the Assessment of Physical Activity in Frail Older People APAFOP, Hauer et al found that many of those with poor cognitive function (MMSE<20) could not perform a very simple interview based physical activity scale (Hauer et al., 2011). In the current study the mean MMSE was 18.7 suggesting most residents would not be capable of completing any form of self-completed scale. Using activity monitors on participants with poor cognition was difficult due to loss of the monitors. A scale filled in by staff does not require any active participation from residents, nor does it risk loss of expensive equipment.

As well as being highly correlated to actual activity, the scale was also related to other measures of physical performance including strength, gait and balance. The same was found in another physical activity scale (Delbaere et al., 2010b). Participants who went on to fall in the subsequent 6 months had significantly lower levels of physical activity using the PAM-RC scale in univariate analysis. However, it was not an independently significant predictor when adjusted for other significant variables. This may be because although lower levels of activity were generally related to more falls, falls rates started to rise again in those with highest activity levels suggestive of a non-linear pattern.

Walking and balance ability questions were included in the scale as it was felt that mobility function would have an important bearing on activity levels in this population. The theory being that the more independent would have more opportunity to be active. When ability and activity subsections from the PAM-RC were analysed separately, the activity subcomponent had a stronger relationship with the activity monitor data. Understandably the abilities subcomponent demonstrated slightly stronger correlations between measures of walking and balance function. It was also possible that a simple question of walking frequency would suffice. However, overall the construct validity was better for the total score than either the abilities or activities subcomponents or the walking frequency question. The full scale also had better internal consistency.

One of the most striking findings is the low level of physical activity in this population. The median time spent lying or sitting down equated to most of the day (22.1 hours). The median number of steps taken was less than 2000, only one fifth of the daily steps recommended for health benefits (Tudor-Locke and Bassett Jr, 2004) and significantly lower than the average 6000 recorded by community dwelling older people (Harris et al., 2009).

These findings suggest that increasing activity levels without addressing falls risk factors could potentially increase falls rates through increased exposure. However, increasing physical activity brings wide ranging health benefits and improves mood, sleep patterns and quality of life (Kesaniemi et al., 2001). Given the undisputed benefits of physical activity, the next step would be to investigate how to optimise activity levels while minimising the risk of falling. This will necessitate taking into account the complex interaction of falls risk factors in this population.

5.4.1 Limitations

There are several limitations to this study. It is acknowledged that a small sample was used and a larger validation study is required to confirm these findings. Sensitivity of this scale to change will need testing to determine whether it is possible to identify changes as a result of an intervention.

In order to measure the difference between sitting and standing, the activity monitor must be placed on the front of the thigh. This makes it easy to remove. Various methods to attach the monitor were used and care staff were educated about its presence but during the course of the study, 8 participants removed and hid them resulting in the loss of three monitors. Considering these losses, the feasibility of using activity monitors in their current form in the severely cognitively impaired is questionable.

The sample used in this study excluded those who could not engage enough to be able to undertake the assessments required as well as those thought to be at high risk of losing a monitor, so did not capture activity data on the most cognitively impaired. However, the

range of ACE-R scores suggests participants had a broad range of cognitive abilities that were not particularly skewed towards better function.

5.4.2 Conclusion

The PAM-RC is a quick and easy to use scale which provides a measure of physical activity in residential care dwellers and can be applied to all including those with severe cognitive impairment and the very physically frail. It has excellent test retest reliability and internal consistency and good construct validity.

The PAM-RC used to measure physical activity in the context of the detailed risk factor study of chapter 4, identified that physical activity levels may have an impact on falls risk but it was less important than other key risk factors.

Defining Falls Risk Factors in Older Adults with Cognitive Impairment Living in Residential Care

Chapter 6

Development and validation of a fall-related impulsive behaviour scale for residential care

6 Development and validation of a fall-related impulsive behaviour scale for residential care

6.1 Introduction

The reasons for increased fall risk in older people with cognitive impairment are multi-factorial and include an increased prevalence of risk factors present in older people without dementia such as gait and balance impairments as well as specific dementia related cognitive deficits and behavioural and psychological symptoms (Whitney et al., 2012). Impulsivity has been postulated to be a risk factor for falls (Scott et al., 2007), but this behavioural factor in the context of falls risk has not been defined and within the psychiatric literature this term is used to describe a variety of personality types and behaviours (Evenden, 1999).

Moeller defined impulsivity as "behaviour without adequate thought including elements such as acting on the spur of the moment, inattention to the task and lack of planning"(Moeller et al., 2001) but many other definitions of impulsivity also exist. Impulsiveness can occur along a spectrum ranging from mild impulsive personality traits to psychopathology. Impulsivity constructs fall into three major categories; difficulty with sustained attention, poor concentration and lack of forward planning described as "acting without thinking"(Patton et al., 1995), risk taking or conscious sensation seeking described as "seeking new and exciting experiences"(Cloninger, 1987) and inability to control impulses or lack of self-control described as "trouble controlling impulses or difficulty waiting"(Lecrubier et al., 1995). Impulsivity has also been classified as either venturesome where a conscious decision has been made to take a high risk option as opposed to unconscious impulsivity, where a risk is taken without a consideration of the risk (Eysenck, 1993).

Impulsivity in people with dementia has been found to reflect lack of forward planning and sustained attention rather than risk or sensation seeking (Rochat et al., 2008) and impulsive and unsafe behaviours have been found to be one of the most common disruptive behaviours in residential care settings (Clifford et al., 2005). Two studies have identified impulsivity as contributing to around one third of falls in hospital inpatients (Harrison et al., 2010, Ferrari et al., 2010). However, as impulsivity in this context has not been clearly defined or operationalised; a simple, valid and reliable impulsive behaviour scale could assist in the care and management of older people with cognitive impairment living in residential care. The aim of this chapter, therefore, was to develop and evaluate the validity and reliability of a new fall-related impulsive behaviour scale (FIBS) for use in residential care.

6.2 Methods

6.2.1.1 Participants

Impulsivity data were collected from all participants of the screening study (chapter 3) and detailed study (chapter 4). The questionnaire was validated using data collected from the detailed study (chapter 4) but the larger data set (chapter 3) was used to determine the role of impulsivity in fall risk. See the methods (chapter 2) for details of inclusion and exclusion criteria.

The South London and Maudsley and Institute of Psychiatry joint ethics committee approved the study and informed consent for participation in the study was obtained from the participants or from legal carers.

6.2.1.2 The fall-related impulsive behaviour scale (FIBS)

The FIBS assessed impulsive behaviour over the previous week and was designed to be answered by a carer who knew the resident well. The questionnaire was drafted by the authors and then reviewed by five carers for comments, revised and then piloted in 10 residents. Following further redrafting, the final scale comprising four questions was produced.

The first FIBS question was "Is *resident n* impulsive*?"* where impulsivity was operationalised as "rushing to carry out an activity without thinking about it first". One point was given if the answer was yes and none if the answer was no. To identify impulsive actions during mobility tasks three further questions were asked:

How often does the resident do the following?

- Try to sit down before getting right up to the chair / toilet / bed?
- Attempt to stand before wheelchair brakes have been applied / footplates moved or walking frame placed in front of them?
- Try to walk without help when asked not to?

The answers to these questions were graded as: never/NA (=0), occasionally (=1), often (=2), frequently (=3) or very frequently (=4). The FIBS score was calculated by summing the scores for the four questions. Carers were asked all 4 questions regardless of the answer to question 1.

The FIBS was repeated after 1 week in a random selection of 30 residents (28% of the sample) to determine test-retest reliability.

6.2.1.3 Cognitive, behaviour, affect and mobility measures

Measures of cognition using the Addenbrooke's cognitive examination (ACE-R) (Mioshi et al., 2006), behaviour using the neuropsychiatric inventory (NPI) (Cummings et al., 1994), standing balance (Guralnik et al., 1994), anxiety using the Goldberg Anxiety Scale (GAS) (Goldberg et al., 1988), depression using the Geriatric Depression Scale (GDS) (Yesavage, 1988), the wandering scale from the MDS as well as demographics were collected for each participant. It was noted whether each participant had urinary incontinence as this could influence frequency with which a person tries to get up. The physical activity and mobility in residential care scale (PAM-RC) was used to measure physical activity (chapter 5) in order to determine exposure to falls. Each participant was followed up to record falls using methods described in chapter 2.

6.2.1.4 Statistical analysis

The components of the FIBS were analysed for consistency using Cronbach's alpha. Principal component analysis with varimax rotation was then conducted to identify distinct factors of the FIBS based on eigenvalues of >1. Test-retest reliability of the FIBS was assessed with analysis of differences in the means using t tests and 95% confidence intervals of the mean difference. Variability of the data was presented as SEM and %SEM and the correlation between the first and second measure analysed using intra-class correlation coefficients (see chapter 2 for more details on analysis of test retest reliability).

Continuously scaled data were analysed for positive skewness and log transformed if necessary to permit parametric analysis. Pearson's correlation coefficients were used to measure convergent validity between FIBS scores and NPI total and sub-components, the wandering score and ACE-R total and sub-scores. Pearson's correlations were also used to

check for divergent validity (i.e. little association) between impulsivity scores and measures of anxiety, depression, physical activity and balance. This was to determine whether other variables possibly linked with impulsivity could be responsible for falls risk such as high impulsivity score reflecting higher levels of physical activity increasing exposure to falls.

To determine validity to predict falls, differences in impulsivity scores between fallers and non-fallers were calculated using group t- tests. The impulsivity measure was also dichotomised using the Youden index (Ruopp et al., 2008) and the odds of impulsive behaviours increasing the risk of falls was calculated using logistic regression analysis while adjusting for potential confounders. This was performed with the detailed and screening study populations. All data analyses were conducted using SPSS version 19.

6.3 Results

Data presented is from the detailed study cohort unless otherwise specified.

One hundred and nine residents from seven residential care homes completed the follow up for this study. See chapter 4 for full demographic details. Forty seven participants (43%) had urinary incontinence, 39 (36%) used a walking frame and 28 (26%) were taking antidepressant medication.

6.3.1.1 FIBS

The mean total FIBS score was 1.39 (±2.72) with scores ranging from zero to the maximum possible score of 13, with 40% of participants exhibiting signs of impulsivity. Scores were positively skewed (skew score 2.6) but improved with log transformation. Therefore, all analysis was performed using log scores. Individual scores for each of the questions are provided in Table 4.13.

Frame users and those taking antidepressants had higher impulsivity scores but there was no difference in impulsivity scores between those with and without urinary incontinence (Table 6.1).

Table 6.1 Differences in impulsivity scores in dichotomous data

Variable	**Impulsivity score mean (SD)**		**P value**
	No	Yes	
Sex = female	0.82 (1.86)	1.71 (3.06)	0.06
Fall in last year	1.10 (2.05)	1.46 (2.85)	0.64
Frame user	0.96 (2.14)	2.18 (3.42)	0.04
Urinary incontinence	1.06 (1.87)	1.83 (3.52)	0.77
Antidepressant use	1.10 (2.14)	2.25 (3.86)	0.04
Anxiolytic /hypnotic	1.40 (2.79)	1.38 (1.60)	0.15
Antipsychotic	1.37 (2.84)	1.53 (2.03)	0.33
2+ medical conditions	1.20 (2.28)	2.00 (3.73)	0.44
>5 medications	0.82 (1.86)	1.71 (3.06)	0.06

6.3.1.1.1 Internal structure

The Cronbach's alpha for the FIBS was 0.77. This was only slightly improved by removing the first question (Table 6.2).

Table 6.2 Chronbach's α with items removed

	Chronbach's α
All questions	0.77
Omitting question 1	0.79
Omitting question 2a	0.77
Omitting question 2b	0.64
Omitting question 2c	0.60

All four questions were significantly correlated with each other, the mean inter-item correlation being r=0.48 (ranging 0.35-0.79).

Table 6.3 Correlations between items

Question	1	2a	2b	2c
1		0.35**	0.40**	0.46**
2a	0.35**		0.42**	0.47**
2b	0.40**	0.42**		0.79**
2c	0.46**	0.47**	0.79**	

** = P<0.001

Factor analysis revealed only one factor with all four questions loading highly (question 1=0.68, 2=0.70, 3=0.86 and 4=0.89). Sixty two percent of the variance in the questionnaire was explained by these questions.

6.3.1.1.2 Test retest reliability

There was no difference between the two repeated scores and the intraclass correlation coefficients were good. There was some (49%) variability in the questionnaire.

Table 6.4 Test retest reliability data

Mean 1 (SD)	2.47 (3.04)
Mean 2 (SD)	2.33 (3.30)
Mean difference (95%CI)	-0.13 (-0.75-0.49)
T test (df)	0.44 (29)
Significance	0.67
SEM (%SEM)	1.18 (49%)
ICC (95%CI) [2,1]	0.93 (0.84-0.96)

6.3.1.1.3 Convergent validity

FIBS (log) scores were strongly correlated with wandering scores, the NPI and ACE-R scores (see Table 6.5). The individual domains of the NPI that were most strongly related to impulsivity were anxiety, disinhibition, irritability, motor disturbance and

disruptive/disturbed night time behaviour scores. The domains of the ACE-R most strongly related to impulsivity were attention and orientation and fluency scores.

Table 6.5 Convergent validity of FIBS

	Relationship to Impulsivity score	
	R	P
ACE-R	-0.20	0.04
Attention and orientation	-0.22	0.02
Memory	-0.16	0.09
Fluency	-0.22	0.02
Language	-0.13	0.19
Visuopatial	-0.14	0.16
NPI	0.43	<0.001
Delusions	0.00	0.99
Hallucinations	-0.03	0.80
Agitation	0.01	0.89
Depression	0.13	0.18
Anxiety	0.45	<0.001
Elation	0.12	0.22
Apathy	0.24	0.01
Disinhibition	0.33	0.001
Irritability	0.36	<0.001
Motor disturbance	0.25	0.008
Night time behaviour	0.42	<0.001
Appetite	-0.07	0.46
Wandering	0.33	0.001

6.3.1.1.4 Divergent validity

There was no significant association between FIBS scores and balance, depression, physical activity or age. There was a trend towards impulsivity being associated with higher levels of anxiety (see Table 6.6).

Table 6.6 Divergent validity

	Relationship to Impulsivity score	
	r=	P=
Standing balance	-0.16	0.09
Goldberg Anxiety Scale	0.19	0.05
Geriatric Depression Scale	0.05	0.62
Physical activity (PAM-RC)	-0.09	0.35
Age	0.09	0.38

6.3.1.1.5 Predictive validity

Detailed study

Fifty three of the 109 participants (49%) fell one or more times during the six month follow-up period. Fallers had significantly higher FIBS scores than non-fallers: 1.83 (±3.08) and 0.96 (±2.28) respectively, t_{107}=2.93, p=0.004. Residents with FIBS scores >1 (determined from the Youden index) had a 2.92 increased odds of falling (95%CI 1.03-8.29) after adjustment for ACE-R, NPI and wandering.

Screening study

One hundred and twenty one (50.4%) of the 240 participants in this study fell one or more times during the six month follow up. Fallers had significantly higher FIBS score than non-fallers: 1.08 (±2.20) and 2.02 (±2.92) respectively, t_{231}=3.11, p=0.002. Residents with FIBS scores >1 had an odds ratio for falling of 2.72 (95%CI 1.44-5.11) after adjustment for cognition (mini mental state examination), NPI and wandering.

When combined with the wandering question, the FIBS was an independent predictor of falls in this cohort (see chapter 3).

6.4 Discussion

The study findings provide good evidence that the FIBS is a simple, valid and reliable scale for assessing fall-related impulsivity in care home residents. The FIBS's predictive validity was established through its ability to discriminate between fallers and non-fallers assessed during a 6-month follow-up period and the scale had good internal consistency and test retest reliability. The FIBS was significantly correlated with similar dementia related behaviours (wandering frequency and NPI total and sub-component scores) indicating good convergent validity and the insignificant associations between FIBS scores and measures of depression,

balance and physical activity levels is indicative of good divergent validity, suggesting high FIBS scores are not reflections of these different constructs.

The pattern of associations between FIBS scores and other measures provides some insight into the mechanisms by which impulsivity may lead to falls in older people with cognitive impairment. Impulsivity was not related to physical activity which suggests that impulsive behaviour does not contribute to falls risk by increasing time spent walking and therefore exposure to falls. Instead it appears impulsivity, as measured by the FIBS, reflects poor concentration and lack of forward planning. This is in line with findings from previous studies (Harrison et al., 2010, Ferrari et al., 2010) and supported by significant association found here between FIBS scores and the attention and orientation section of the ACE-R scale. It is also interesting to note that those taking anti-depressants were more likely to be impulsive. Impulsive behaviours are thought to be modulated through serotonergic systems and serotonin reuptake inhibitors and tricyclic antidepressants have been used to treat pathological impulsivity (Evenden, 1999). There was no significant relationship between depression and impulsivity and since when analysed using logistic regression analysis both use of antidepressants and impulsivity were both significant and independent predictors of falls, it is unlikely that the behaviour resulted from or caused antidepressant prescription.

6.4.1 Limitations

Frame users were more likely to be judged impulsive. It is acknowledged that frame users had more opportunity to be classified as impulsive as FIBS questions were based around preparing to undertake activities (i.e. waiting for the frame to be placed in front). However, frame users who require a frame due to poor balance and mobility, would be more likely to fall if they forgot to use it due to impulsive behaviour. It could be concluded therefore that

this test identifies impulsive behaviours when they are likely to result in falls and not impulsive behaviours per se. Second, the sample was relatively small and although the study was conducted in seven care homes, these findings require external validation. Third, there is no data on sensitivity to change dependent on interventions to address such behaviours. Finally, since FIBS asks carers about behaviours, it is not possible to definitively diagnose residents as impulsive as it does not measure personality traits but behaviours for which there are several possible causes. However, in a population with high levels of cognitive impairment, administration of questionnaires to determine personality may not be feasible and since the behavioural manifestations are what leads to falls, these aspects of impulsivity appear important to measure.

6.4.2 Conclusion

The FIBS is a simple, valid and reliable scale for assessing fall-related impulsivity in care home residents and could be appropriate for use in this group for both research and clinical purposes.

Defining Falls Risk Factors in Older Adults with Cognitive Impairment Living in Residential Care

Chapter 7

Balance judgement does not predict falls in older residential care dwellers with cognitive impairment

7 Balance judgement does not predict falls in older residential care dwellers with cognitive impairment

7.1 Introduction

Older people with cognitive impairment are at higher risk of falling than those who are cognitively intact (Tinetti et al., 1988a). There are many possible reasons for this. One manifestation of cognitive dysfunction is impaired judgement. Judgement has been defined as "the capacity to make a decision after consideration of available information, contextual factors, possible solutions and probable outcomes" (Vale Capucho and Dozzi Brucki, 2011). Judgement or decision making is considered an executive function but also requires memory, perception, language and attention.

There is evidence that judgement is impaired in cognitive impairment and dementias (Perneczky et al., 2006, Delazer et al., 2007) but there are a lack of well validated tests of judgement to use in this population (Vale Capucho and Dozzi Brucki, 2011). Many of the tools available to measure judgement include assessment of instrumental activities of daily living (Loeb, 1996) to evaluate problem solving or gambling tasks to determine judgement of risk (Brand and Markowitsch, 2010). These tools measure overall judgement, whereas judgement specifically relating to balance function may be of more interest when investigating risk factors for falling. Impaired balance increases falls risk (Cho and Kamen, 1998) and this risk may be modified by adopting appropriate behaviour in relation to the extent of the balance deficit. The perceived reach test was developed and examined to determine the effect of balance judgement on falls risk in a population of older people with cognitive impairment.

7.2 Method

7.2.1.1 Participants

Participants from the detailed risk factor study (chapter 4) took part in this study. Informed consent for participation in the study was obtained from the participants or from legal carers. The South London and Maudsley and Institute of Psychiatry joint ethics committee approved the study.

7.2.1.2 The perceived reach test

Participants carried out this test in the order described below. Each participant completed the test three times. They were asked not to use external support during the actual reach test but support could be used while they were standing and estimating reach.

7.2.1.2.1 Perceived reach from the step

Only participants who could get onto a 25cm step took part in this part of the test. Participants started the test standing on the step. A vertical rod was attached to a perpendicular metre rule, placed on the floor extending anteriorly from the step. The participant was asked to estimate when they "thought" they could reach the rod as the rod was slowly moved towards the participant. When they indicated they thought they could reach the rod, it's distance from the step was noted (Figure 7.1).

Figure 7.1 Perceived reach from the step

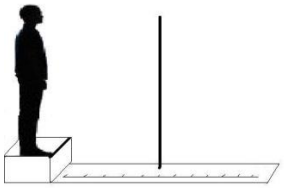


Figure 7.2 Perceived reach from the floor

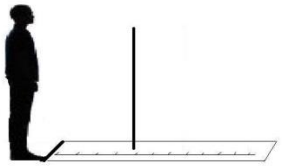
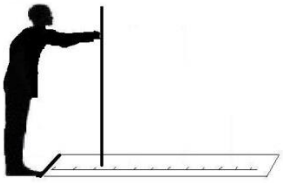


Figure 7.3 Actual reach measurement



7.2.1.2.2 Perceived reach from the floor

All participants who could stand took part in this test. They stood on the floor with feet shoulder width apart and toes aligned to a marker (from which the metre rule extended anteriorly). The vertical rod as previously described was again moved towards the participant and stopped at the distance at which the participant thought they could reach it and the distance noted (Figure 7.2).

7.2.1.2.3 Actual reach

The participant remained standing on the floor with the toes aligned to the marker with the vertical rod in the start position. They were then asked to reach as far forward as possible without using any external support and the rod moved to the end of the longest fingertip and the distance recorded (Figure 7.3).

7.2.1.3 Cognitive, balance, gait and mobility measures and falls follow up

Cognition was assessed using the Addenbrooke's cognitive examination (ACE-R)(Mioshi et al., 2006) and behaviour was assessed using the neuropsychiatric inventory (NPI)(Cummings et al., 1994). Anxiety and depression were measured using the Goldberg anxiety scale (Goldberg et al., 1988) and Geriatric depression scale (Yesavage, 1988). Impulsivity was measured using a questionnaire (described in chapter 6). Participants also underwent assessments of grip strength, standing balance-total balance score (Guralnik et al., 1994), mobility (timed up and go (Podsialdo and Richardson, 1991) and 6 metre walk), and the Barthel index (Mahoney and Barthel, 1965)). Vision was measured using the Melbourne edge test (Verbaken and Johnston, 1986). Falls were measured for the subsequent 6 months as specified in the methods section (chapter 2).

7.2.1.4 Data analysis

Descriptive data was presented for the perceived and actual reach scores in millimetres. The mean of the 3 tests was calculated and the reach distances were adjusted for height using the equation $\frac{Reach\ distance \times average\ height}{Actual\ height}$.

The reliability between each test (performed 3 times) was analysed using intraclass correlation coefficients.

Since the actual reach was designed to be a measure of balance, the correlation between it and the total balance score as determined using Pearson's correlation coefficients.

The difference between perceived reach (PR) on the step and PR on the floor and PR floor and actual reach were analysed using paired t-tests. Difference scores were created for PR step-floor to examine the difference in estimated reach between standing on a step and

standing on the floor. The following calculation: $PR\ step\ -PR\ floor$ was used. The second difference score was between PR on the floor and actual reach. The following calculation: $PR\ floor\ -Actual\ reach$ was used. The difference scores were then divided into tertiles. Differences in physical, cognitive and behavioural measures between the tertiles were analysed using one way ANOVAs.

The percentage error in perceived reach was calculated $\frac{Actual\ reach-PR\ floor}{Actual\ reach}\ x100$ and split into tertiles, to look for differences in physical, cognitive and behavioural measures using methods as above.

Mean reach scores, difference scores and percentage error were analysed for differences between fallers (≥1 fall(s)) and non-fallers using unpaired t tests. Reach distance was dichotomised using the Youden index to determine optimal sensitivity and specificity with respect to faller status (Ruopp et al., 2008). Using the identified cut points, risk of falling was then calculated using the relative risk statistic and risk of falls calculated using negative binomial regression analysis. Finally, the differences in faller status within each of the tertiles were analysed using chi square statistics. SPSS version 19 and STATA version 12 were used for all analysis.

7.3 Results

Sixty eight (62%) of the 109 potential participants were physically capable of standing up long enough to complete the test. Of these 52 were able to stand on the step. Table 7.1 provides details of participants who could and could not undertake the test. Being able to do the test, particularly the test from the step was associated with better physical and cognitive function.

Table 7.1 Differences between those who could and couldn't complete perceived reach tests

	Unable to do any test N=41	**Able to do PR from floor N=16**	**Able to do PR from step N=52**
	Mean (SD)	Mean (SD)	Mean (SD)
Age	86.0 (8.8)	83.2 (7.8)	83.8 (8.1)
Barthel (0-100)**	45.4 (25.8)	60.6 (20.2)	78.0 (14.0)
Grip strength (Kg)*	8.2 (5.1)	11.3 (9.1)	13.3 (7.6)
Timed up and go (secs)**	129.6 (82.8)	93.1 (64.8)	30.6 (24.4)
6 metre walk (secs)**	69.3 (44.2)	48.6 (38.5)	13.1 (10.0)
Balance score (0-5)**	0.8 (1.0)	1.1 (0.9)	2.6 (0.9)
Goldberg anxiety scale (0-9)	2.3 (2.5)	2.8 (3.3)	2.0 (2.1)
Geriatric depression scale (0-15)*	5.8 (2.1)	6.3 (3.2)	4.0 (3.4)
NPI (0-144)	18.1 (19.1)	13.3 (10.8)	14.5 (15.1)
Impulsivity (0-13)	1.5 (3.3)	1.3 (1.8)	1.4 (2.4)
ACE-R (0-100)*	31.6 (23.7)	50.4 (16.7)	44.2 (18.1)
Falls per year	3.1 (6.1)	3.0 (4.0)	1.8 (2.9)

** P<0.001 on one way ANOVA
* P<0.01 on one way ANOVA

PR and actual reach data are presented in Table 7.2. Total balance score was not related to perceived or actual reach scores (PR step r=0.05, PR floor r=0.08 and actual reach r=0.10). Intraclass correlation coefficients (95%CI) were 0.94 (0.91-0.96) for PR step, 0.98 (0.97-0.99) for PR floor and 0.97 (0.96-0.98) for actual reach between each three repetitions of the test.

Table 7.2 Descriptive data for perceived and actual reach

	Mean (SD)	**Median**	**Range**	**Skew**
Perceived reach step (mm) (average of 3 tests adjusted for height)	667 (136)	666	300-887	-0.50
Perceived reach floor (mm) (average of 3 tests adjusted for height)	666 (150)	666	281-942	-0.46
Actual reach (mm) Average of 3 tests adjusted for height)	662 (105)	663	365-903	-0.52

There were no significant differences between PR step and PR floor (t=-0.30 $df_{51,}$ p=0.77) or between PR floor and actual reach (t=-0.21 $df_{67,}$ p=0.84) (Table 7.3). The mean percentage error was -3.00 indicating a 3% overestimation of actual reach.

Table 7.3 Differences in reach between the step and floor and perceived and actual

	Mean (SD)	Range
PR step - PR floor (mm)	-4.0 (99)	-147-324
PR floor - Actual reach (mm)	4.1 (164)	-492-577
Percentage error	-3.00 (31)	-158-63

The difference scores were split into tertiles and data on physical function, cognition and behaviour were analysed for differences. The only significant difference was that those with a cavalier approach to PR on the step compared to the floor had worse vision on the Melbourne edge test and those with equal strategy, whose reach estimates were similar on the step and floor had better grip strength (Table 7.4).

Table 7.4 Differences in physical function, cognition and behavioural measures between tertiles of difference between PR on the step and floor

PR Step-floor	**Tertile 1 Cautious strategy (PR further on the floor) N=17**	**Tertile 2 Equal strategy (PR the same on step and floor) N=17**	**Tertile 3 Cavalier strategy (PR further on the step) N=18**
Age	83.6 (8.2)	83.8 (8.0)	83.9 (8.4)
Barthel (0-100)	74.1 (16.9)	76.9 (11.7)	12.0 (7.6)
Grip strength (Kgs)	10.8 (5.9)	17.1 (7.9)	12.0 (7.6)*
Timed up and go (secs)	31.9 (20.0)	33.1 (26.2)	27.2 (27.2)
6 metre walk (secs)	15.5 (13.0)	14.1 (10.3)	9.7 (4.5)
Balance score (0-5)	2.6 (1.0)	2.6 (0.8)	2.5 (0.9)
GAS (0-9)	1.9 (2.6)	1.9 (1.9)	2.2 (2.0)
GDS (0-15)	4.5 (4.0)	3.1 (2.6)	4.4 (3.5)
NPI (0-144)	16.0 (12.7)	12.4 (13.2)	15.2 (19.0)
Impulsivity (0-13)	1.8 (2.7)	1.3 (2.7)	1.0 (1.9)
ACE-R (0-100)	46.6 (18.7)	46.5 (18.8)	39.8 (18.9)
MET (1-24)	13.8 (4.9)	16.4 (3.2)	10.4 (4.3)**

* $p<0.05$, ** $p<0.001$
Tertile 1 <-57mm, tertile 2 = -57mm-15mm, tertile 3 >15mm

There were no significant differences between any of the baseline measures collected for PR floor - actual reach difference scores (Table 7.5) neither were there any significant differences in percentage error tertiles (Table 7.6).

Table 7.5 Differences in physical function, cognition and behavioural measures between tertiles of difference between PR on the floor and actual reach

Mean floor PR-Actual reach	**Tertile 1 Cautious strategy Underestimates N=22**	**Tertile 2 Equal strategy Accurate estimate N=23**	**Tertile 3 Cavalier strategy Overestimates N=23**
Age	82.7 (8.6)	84.7 (7.8)	83.5 (7.6)
Barthel (0-100)	75.7 (16.4)	77.3 (15.1)	68.9 (19.4)
Grip strength (Kgs)	14.3 (8.1)	12.1 (6.8)	12.0 (9.0)
Timed up and go (secs)	47.1(55.9)	36.7 (33.7)	52.2 (46.4)
6 metre walk (secs)	21.6 (30.6)	18.3 (21.5)	24.3 (23.9)
Balance score (0-5)	2.2 (1.0)	2.5 (1.2)	2.1 (1.2)
GAS (0-9)	2.6 (2.9)	2.1 (2.4)	1.9 (2.1)
GDS (0-15)	5.5 (3.9)	4.2 (3.4)	3.9 (3.0)
NPI (0-144)	11.4 (11.5)	16.3 (13.5)	14.9 (16.9)
Impulsivity (0-13)	1.0 (1.9)	1.5 (2.4)	1.5 (2.6)
ACE-R (0-100)	43.5 (18.0)	47.7 (19.2)	45.7 (16.8)
MET (1-24)	12.1 (6.2)	13.8 (5.0)	13.4 (4.9)

Tertile 1 <-64mm, tertile = -64mm-42mm, tertile 3 >42mm

Table 7.6 Differences in physical function, cognition and behavioural measures between tertiles of percentage error in PR

Percentage error	**Tertile 1 Underestimates N=23**	**Tertile 2 Accurate estimate N=23**	**Tertile 3 Overestimates N=22**
Age	83.7 (8.8)	83.7 (7.5)	83.4 (7.8)
Barthel (0-100)	75.4 (16.3)	76.2 (16.3)	70.0 (19.1)
Grip strength (Kgs)	13.8 (8.2)	12.1 (6.9)	12.5 (8.9)
Timed up and go (secs)	43.6 (53.6)	39.7 (36.0)	53.1 (47.3)
6 metre walk (secs)	20.0 (29.5)	20.0 (22.1)	24.4 (24.4)
Balance score (0-5)	2.3 (1.0)	2.3 (1.2)	2.1 (1.2)
GAS (0-9)	2.6 (2.8)	2.0 (2.5)	2.0 (2.1)
GDS (0-15)	5.4 (3.9)	4.4 (3.4)	3.9 (3.0)
NPI (0-144)	12.0 (11.2)	15.5 (13.9)	15.4 (17.1)
Impulsivity (0-13)	1.2 (2.0)	1.3 (2.3)	1.5 (2.6)
ACE-R (0-100)	42.6 (19.6)	49.1 (17.0)	45.3 (17.1)
MET (1-24)	11.7 (6.2)	14.3 (4.6)	13.5 (5.0)

Tertile 1 < -6, tertile 2 = -6 – 9, tertile 3 >9

7.3.1.1 Falls follow up

Of the 52 participants able to complete PR from the step, 21 (41%) of these fell 1 or more times in the 6 month follow up period. Of the 68 able to perform PR from the floor, 30 (44%) fell one or more times.

There were no differences in PR and actual reach measures, difference measures or percentage error scores between fallers and non-fallers (Table 7.7).

Table 7.7 Difference in reach scores between fallers and non-fallers

	Non-faller Mean (SD)	N	Faller Mean (SD)	N	P
PR step (mm)	682 (137)	31	643 (135)	21	0.3
PR floor (mm)	693 (143)	38	631 (152)	30	0.09
Actual reach (mm)	676 (95)	38	643 (115)	30	0.2
PR Step-floor (mm)	-5.7 (82)	31	-1.6 (121)	21	0.9
PR floor- actual reach (mm)	17.2 (181)	38	-12.4 (142)	30	0.5
Percentage error	-5.8 (34.9)	38	0.5 (26.1)	30	0.4

However, when PR step, floor and actual reach distances were dichotomised using the Youden index to determine optimal cut points for faller status, lower perceived and actual reach on the floor were associated with increased falls risk and falls rates (Table 7.8).

Table 7.8 Differences in faller status using dichotomised data

	Cut point	Non-fallers N (%)	Fallers N (%)	RR (95%CI)	IRR (95%CI)
PR step (mm)	<659mm	10 (48%)	11 (52%)	1.42 (0.85-2.37)	1.66 (0.71-3.91)
PR floor (mm)	<694mm	17 (43%)	23 (58%)	1.77 (1.16-2.68)	2.32 (1.00-5.41)
Actual reach (mm)	<601mm	4 (27%)	11 (73%)	2.41 (1.02-5.70)	2.14 (1.02-4.50)

Analysing faller status per tertile revealed no significant difference in PR step-floor, PR floor-actual and percentage error (Table 7.9).

Table 7.9 Differences in fall rates per tertile

Mean PR Step-floor	**Tertile 1 Cautious strategy (PR further on the floor) N=17**	**Tertile 2 Equal strategy (PR the same on step and floor) N=17**	**Tertile 3 Cavalier strategy (PR further on the step) N=18**
Faller N (%)	8 (47%)	5 (29%)	8 (44%)
Mean floor PR-Actual reach	**Tertile 1 Cautious strategy Underestimates N=22**	**Tertile 2 Equal strategy Accurate estimate N=23**	**Tertile 3 Cavalier strategy Overestimates N=23**
Faller N (%)	11 (50%)	11 (48%)	8 (35%)
Percentage error	**Tertile 1 Underestimates N=23**	**Tertile 2 Accurate estimate N=23**	**Tertile 3 Overestimates N=22**
Faller N (%)	11 (48%)	11 (48%)	8 (36%)

7.4 Discussion

The perceived reach test was performed in participants able to stand unsupported. Although perceived reach on the floor and actual reach from the floor were associated with increased falls risk when they were dichotmised into high on low risk groups, there were no other significant fall related differences and few other differences in baseline variables dependent on reach judgement.

The finding that poor judgement is not associated with falls risk, but reaching distance is, has been identified in a previous study in cognitively intact community dwelling older people (Butler et al., 2011). Robinovitch studied this in young and middle aged people and found that this group significantly underestimated bending reach and suggested this was an "inherent safety mechanism" that prevented reaching out of limits of stability (Robinovitch, 1998). When the same authors investigated older people including nursing home residents, there was no significant difference between perceived and actual reach distance (Robinovitch and Cronin, 1999). The current study findings, confirm Robinovitch's conclusion that older people do not significantly underestimate and therefore lack this "safety factor".

A small study investigating reach error found that those with poor working memory were more likely to overestimate reaching ability (Liu-Ambrose et al., 2008a). Those findings were not repeated in this study where no relationship between cognition and reach difference or percentage error was found. Liu-Ambrose used a cohort who were cognitively intact (MMSE>24) whereas the current study only included the cognitively impaired. There may be a threshold at which executive dysfunction impacts on reach judgement with most of the participants of the current study falling below this threshold.

While there was no statistically significant difference between reach judgement and fallers, there was a trend towards non-fallers overestimating reach distance and fewer overestimators falling in the 6 month follow-up. This was despite the fact that the oversestimators demonstrated a trend towards worse gait and balance function. These findings may be explained by the psychological approach to falls risk. Delbaere found a protective effect against falls in older people at high risk of falls based on physiological impairments but who perceived themselves to be at low risk (Delbaere et al., 2010a). Although, there are only trends to suggest this, it may be that a "stoic" mind-set is also protective in this population.

7.4.1 Limitations

There are several limitations to this study. It was a small study with only 68 participants from 7 residential homes, therefore it would require confirmation in another population. One of the reasons for the small numbers, was that participants had to be able to stand for long enough to perform the test and in this frail population, there were a significant proportion of people who couldn't do this. A test performed in sitting may allow more participants to be recruited but such a test would be less relevant to standing balance.

Actual reach was not related to the other balance measures used, measures which were found to be significantly associated with increased falls risk (chapter 4). Actual reach was measuring leaning balance unlike the total balance score which measured time spent in increasingly difficult static balance positions.

It could be argued that participants with cognitive impairment did not understand the instructions which resulted in the inconclusive result. However, the intraclass correlation coefficients demonstrated excellent reliability between measurements suggesting that results

were repeatable and therefore not misunderstood. Visual impairment may have also influenced results and those who estimated further standing on the step than on the floor did have worse vision. However, vision was not different in tertiles based on PR floor-actual reach and percentage error.

7.4.2 Conclusion

Previous work identified that frail older people fail to underestimate reach distance which may actually be a pathological loss of a "safety mechanism". This study also found that many older people with cognitive impairment do not underestimate reach distance. However, there was no evidence from this study that underestimating decreased falls risk. Therefore, it could be concluded that impaired balance judgement is not a falls risk factor in older adults with cognitive impairment. However, non-linear relationships between falls and balance judgement and an interaction with the psychological approach to falls risk may mask any significant findings and further work to understand this is required.

Defining Falls Risk Factors in Older Adults with Cognitive Impairment Living in Residential Care

Chapter 8

Discussion

8 Discussion

8.1 Summary of findings

This thesis presents data collected from a large cohort of older people living in residential care. Prospective data was collected to determine fall risk factors in this population with the ultimate aim of designing an effective intervention tailored to this population.

The first study (chapter 3) used easily collectable data to produce a falls risk screening tool for older people living in care homes. Based on a cohort of 240 residents, it identified 7 independent and significant predictors of falls which were, use of antidepressants, hypnotics/anxiolytics, requiring a walking frame, impulsive behaviour, poor standing balance, previous falls and cognitive impairment. All of the participants who had 6 or more of these risk factors fell in the 6 month follow up period. This screening tool is simple to complete and effective at identifying those at high risk of falls in this population.

The second study (chapter 4) examined falls risk factors in detail. One hundred and nine participants with cognitive impairment completed detailed baseline assessments of health, balance and sensorimotor function, behaviour and cognition. Falls were recorded for the subsequent 6 months. This study identified that falls risk in this population is multifactorial and risk factors included poor gait and balance, antidepressant use, dementia related behaviours, anxiety, impulsivity and poor cognition, particularly the domains of attention, orientation and concentration. This is the first study to comprehensively analyse such a range of potential risk factors and these findings will be used to design targeted interventions. The

subsequent 3 chapters dealt with development of methods. Data was collected to develop and validate a physical activity questionnaire for residential care dwellers (PAM-RC) and a falls related impulsive behaviour scale (FIBS) which both demonstrated good construct validity and psychometric properties. Both scales were able to discriminate between fallers and non-fallers, with impulsivity being an independent predictor in multivariate analysis. A measure of balance judgement was designed but data analysis revealed that poor balance judgement as measured by the perceived reach test was not related to falls in this population.

8.2 How does this population compare to normative data

Table 8.1 illustrates the difference between data collected in these studies and known normative data and cut points for identification of those at high risk of falls. The mean scores from the current research are clinically and significantly lower than both normative data and data that indicates increased risk of falls with the vast proportion of participants scoring below these cut points. This would instantly suggest that the population concerned are at high risk of falls and that they are also clearly physically and cognitively very frail.

8.3 The relationship between cognition and physical function

Commonly identified falls risk factors in community dwelling and care home populations include impairments in gait, balance and sensorimotor function. As already described in the introduction, cognitive dysfunction is often associated with impairments in physical function and it was hypothesised that cognitive impairment would be associated with increased prevalence of known risk factors such as gait and balance dysfunction. Data collected in this current study was analysed to determine whether the extent of cognitive impairment was associated with worse sensorimotor function. In the detailed data collection study, worse cognition measured with the ACE-R was associated with worse vision, slower reaction times,

slower walking speed, higher PPA falls risk scores and worse function measured with the Barthel (Table 4.21). The findings from this study suggests that with worsening cognition, gait and sensorimotor function gets worse, increasing the prevalence of these known risk factors in this population.

Table 8.1 Data collected compared to known norms or cut points

Variable	Normative data	Cut point associated with falls	Means from these studies		Proportion below cut point
			N=109	N=240	N=109
Barthel	100 = independent in basic ADLS	≤19/20 for falls = ≤90/100	57	63	83%
6 metre walk (SMWT)		≥6 seconds	39		98%
Timed up and go (TUAG)		>10 seconds for fit community dwelling older people >15 seconds for those already at high risk of falling	77		100% 88%
Sustaining standing positions		<10 seconds for near tandem standing eyes closed	0.7 seconds		98%
Grip strength		<19Kgs <120mmHg in Women	11Kgs		62%
Sit to stand		≤12 seconds for 5 STS	39 seconds		98%
Goldberg anxiety Scale	>5 for anxiety disorder		2		20%
Geriatric depression scale (15)	>5 to diagnose depression	>5 for falls	5		53%
Addenbrooke's cognitive examination	<82/100 identifies dementia with sensitivity of 0.84 and specificity of 1.0		40		100%
Mini Mental State Examination	Score <24/30 defined as cognitive impairment	<24/30 recurrent falls	15	14	83%
WMS-III Logical memory story 1	≤7 for diagnosis of dementia		3		88%
Trail making test A		Normative data for ages 81-83, 50 percentile scores = 43-52 seconds to complete	214 seconds		100% (52 sec)
Boston naming test (shortened version)		Normative data for midpoint age =83, score 12.7.	5		95%

8.4 Differences between the screening and detailed studies

Those who took part in the screening study were physically frailer at baseline than those who agreed to participate in the detailed data collection (Table 4.22). Fall risk factors were similar in both studies. Some risk factors were significant in the larger screening study probably due to the greater sample size giving the study more power and these included using CNS and hypnotic/anxiolytic medications and requiring a walking frame.

What this data suggests is that there is a bias in which those with better function and cognition are more likely to participate in research trials that require active participation. However, the fact that risk factors in the screening and detailed studies were very similar suggests that the findings of the detailed study could be generalised to a frailer population.

8.5 How do these data contribute to the literature?

8.5.1 Demographic, medical, medication and environmental measures

None of the medical conditions associated with falls risk described in the introduction were related to falls in this study. The only single condition found in the detailed study to be associated with more falls was hypertension. Apart from arthritis, hypertension was one of the most prevalent conditions affecting 40% of the participants. Risk factor conditions such as stroke and Parkinson's disease affected smaller proportions (18% and 2% respectively). It is possible that the symptoms of such conditions are more severe in residential care dwellers to the extent that those with conditions such as stroke and Parkinson's disease are immobile and therefore have lower exposure to falls.

In the detailed study, there was no relationship between falls and symptoms of orthostatic hypotension. It may be that measurement of blood pressure using a sphygmanomometer

rather than beat to beat blood pressure using a finometer was less sensitive and therefore didn't identify all cases. However, there were cases of classical orthostatic hypotension identified, but in equal numbers in fallers and non-fallers. This is contrary to the findings of Allan and colleagues who found that symptomatic orthostatic hypotension and autonomic symptoms were predictors of falls in multivariate analysis in older people with dementia (Allan et al., 2009). Their study was a case control study including equal proportions of participants with Lewy body dementia (DLB) and Parkinson's disease as vascular and Alzheimer's dementias. Those with Parkinson's disease and DLB are more likely to suffer from autonomic dysfunction (Allan et al., 2007) and the prevalence of these two types of dementia in this detailed study were small. Another explanation for this finding could be that in this study, lying/standing blood pressure measurements were performed at random times during the day. There is the possibility that morning or post prandial orthostatic hypotension may have been missed on assessment (Naschitz and Rosner, 2007).

The environmental assessment was no different between fallers and non-fallers. Since homes have standardised room set up and regulated safety assessments of the environments, it is unlikely that environmental risk factors differ significantly within each home or participant.

The current studies reinforced previous research in confirming the role of previous falls and functional impairment as significant risk factors. It also supports work identifying multiple medication use, CNS medications and psychotropic medications particularly hypnotics and anxiolytics, as significant risk factors for falls. Interestingly, it confirms recent findings that antidepressants, particularly serotonin reuptake inhibitors (SSRIs) as important risk factors in this population (Sterke et al., 2012b). The reasons why SSRIs increase falls risk are not yet fully understood. Regular users of SSRIs perform worse on balance tests (Hegeman et al.,

2011) and older people appear to experience more syncopal and orthostatic episodes as side effects (Cherin et al., 1997). In fact in animal studies, cardiac depressive effects have been noted (Pacher and Ungvari, 2001). SSRIs may also be implicated in fall related injury as use is associated with reduced bone mineral density in men (Haney et al., 2007).

8.5.2 Mobility, balance and sensorimotor variables

Sensorimotor variables of vision, sensation and muscle strength were not different between fallers and non-fallers in this study. These variables have consistently predicted falls risk in other studies and it is not clear why they do not predict falls in this population. One reason may be that baseline function was significantly below normal values. Virtually all participants performed very poorly on these tests (Table 8.1). In addition large proportions of participants could not complete these tests either because they could not understand the instructions or were physically incapable (Table 4.3). On the other hand, poor performance in measures of postural sway, standing balance and walking were all associated with increased falls risk. This may relate to the neuropathological process in the central nervous system resulting in the dementia also having an impairing effect on postural stability. In older people without dementia, postural sway can be explained by impairments in strength, reaction times, sensation and vision (Lord et al., 1991b). In this study, postural sway on the floor with eyes open and closed was related only to proprioception and muscle strength, the two variables accounting for 37 and 25% of the variance in sway scores respectively (see Table 8.2 for details of relationships between sway measures and physiological explanatory variables). This suggests that sensorimotor impairments are related to falls risk in cognitively intact older people due to the resulting balance impairment. Those with cognitive impairment also

have impaired balance contributing to falls risk. However, sensorimotor impairments seem not to contribute to balance impairment in the same way in this population.

Table 8.2 Correlations between postural sway and other sensorimotor measures

	Sway floor eyes open ***R***	**Sway floor eyes closed** ***R***
Vision (MET)	-0.18	-0.15
Proprioception	0.56**	0.45**
Hand reaction times	0.13	0.09
Knee extension strength	-0.52**	-0.42**

** P<0.001

8.5.3 Behavioural and psychiatric symptoms

One measure in this domain which was not related to falls was the geriatric depression scale. This was a surprising result as depression has been found in many previous studies to predict falls risk (Tinetti et al., 1988a, Whooley et al., 1999). Firstly, although there was no significant difference, there was a trend towards higher GDS scores in fallers and more fallers having GDS >5. This was supported by the fact that more fallers took antidepressant medication. Unsurprisingly, the GDS scores were significantly worse in those who took antidepressants compared to those who didn't (mean 6.4±3.2 and 4.5 ±2.9 respectively t-2.81^{df107}, p=0.006). Antidepressant use may be a better marker of depression than the GDS. Since the GDS is a questionnaire directed to the participant, it may not be the best way to measure depression in people with cognitive impairment who may not be able to remember or express feelings of depression in this context (Alexopoulos et al., 1988). Therefore, it is possible that depression is associated with falls in this population but the GDS was not the best way of measuring this.

Judgement of balance was not related to risk of falling and is discussed in more detail in chapter 7.

Impulsivity as a falls risk factors has been discussed in detail in chapter 6 and when combined with wandering was found to be an independent predictor of falls in the screening study. This behavioural outcome of inattention and poor concentration appears to be an important falls risk factor in this population. Wandering, when combined with impulsivity scores was significantly associated with increased falls risk. However, as a single question, did not significantly differ between fallers and non-fallers. This was unexpected as wandering had been one of the more consistent behavioural symptoms associated with falls in previous studies (Pellfolk et al., 2009, Kallin et al., 2005). Wandering is a complex risk factor, where on a background of adequate postural stability may be protective of falling on the basis that it increases physical activity levels. On the other hand, wandering on a background of postural instability may dramatically increase risk.

Dementia related behaviours increased the risk of falls as measured using the NPI. The screening study with greater power, identified differences between fallers and non-fallers in the domains of apathy, irritability, night-time disturbance and appetite and in the smaller detailed study only the domains of apathy and irritability were significantly different. The apathy question "does the resident seem less interested in his/her usual activity or the plans and activities of others?" could be indicative of depression or lower levels of physical activity. However, on further investigation there was no relationship between apathy scores and depression (GDS) or physical inactivity (PAM-RC) ($r=0.09$ and $r=-0.16$ respectively). Furthermore, apathy scores were not related to any of the other data collected and therefore cannot be considered to represent any other construct. The irritability question "is the resident impatient and cranky, do they have difficulty coping with delays or waiting for planned

activities" is similar to the concept of impulsivity and this is confirmed by a significant correlation between impulsivity scores and the irritability question (r=0.32, p=0.001).

The importance of anxiety as a falls risk factor in this study was the surprising result of the study. Few studies have previously identified anxiety as a fall risk factor (Vetter and Ford, 1989) but in the detailed study, anxiety was the best predictor of all the behavioural and psychiatric symptoms and was even an independent predictor of falls risk. There are several possible explanations for this outcome. Firstly, anxiety is known to directly affect postural stability (Adkin et al., 2002) although it did not appear to do so in this study (chapter 4). It may be that anxiety was related to fear of falling, a known falls risk factor (Murphy et al., 2003, Friedman et al., 2002) which was not possible to measure effectively in this population. Finally, some of the questions in the Goldberg Anxiety Scale include questions such as "do you feel keyed up or on edge" and "have you felt trembling, tingling…" which could be a manifestation of agitation or irritability. More research is required to better understand the close relationship between anxiety and falls in this population.

8.5.4 Neuropsychological variables

Of all the neuropsychological variables, the only significant measurement tool that discriminated between fallers and non-fallers was the ACE-R. The logical memory story, Boston naming test, hand reaction times and trail making test were not associated with increased falls risk. Most participants performed badly on the latter four tests, well below normal values. It may be that floor effects in these tests in this population limited the tests' abilities to determine the differences between fallers and non-fallers. Examining the ACE-R in more detail identified domains of attention and orientation, memory and fluency as

significant falls risk factors with attention and orientation being an independent predictor of falls.

Language and visuospatial domains were not related to falls risk. Difficulty expressing wishes and needs was postulated to increased falls as a person may be more likely to attempt an unsafe activity if they cannot make themselves understood. This does not appear to be the case as the only significant difference in the language domain was in the sentence writing, which requires an element of executive function, where fallers performed less well. The overall visuospatial score was not different between fallers and non-fallers. This was surprising as it was thought that visuospatial dysfunction would result in difficulties negotiating the environment. However, when examining individual questions, fallers were significantly worse at the overlapping pentagons and cube drawing tests suggesting that some sections of visuospatial function were worse in fallers. This supports previous findings (Ramirez et al., 2010).

Of the attention and orientation domain, the question that best identified fallers was the attention and calculation question. This required spelling the word "world" backwards and/or counting back from 100 in 7s. This question measures attention and concentration. The strong correlation with the impulsivity scale suggests that poor attention and concentration results in impulsive behaviours such as trying to get up without help or walk without a walking aid which in turn increases falls risk.

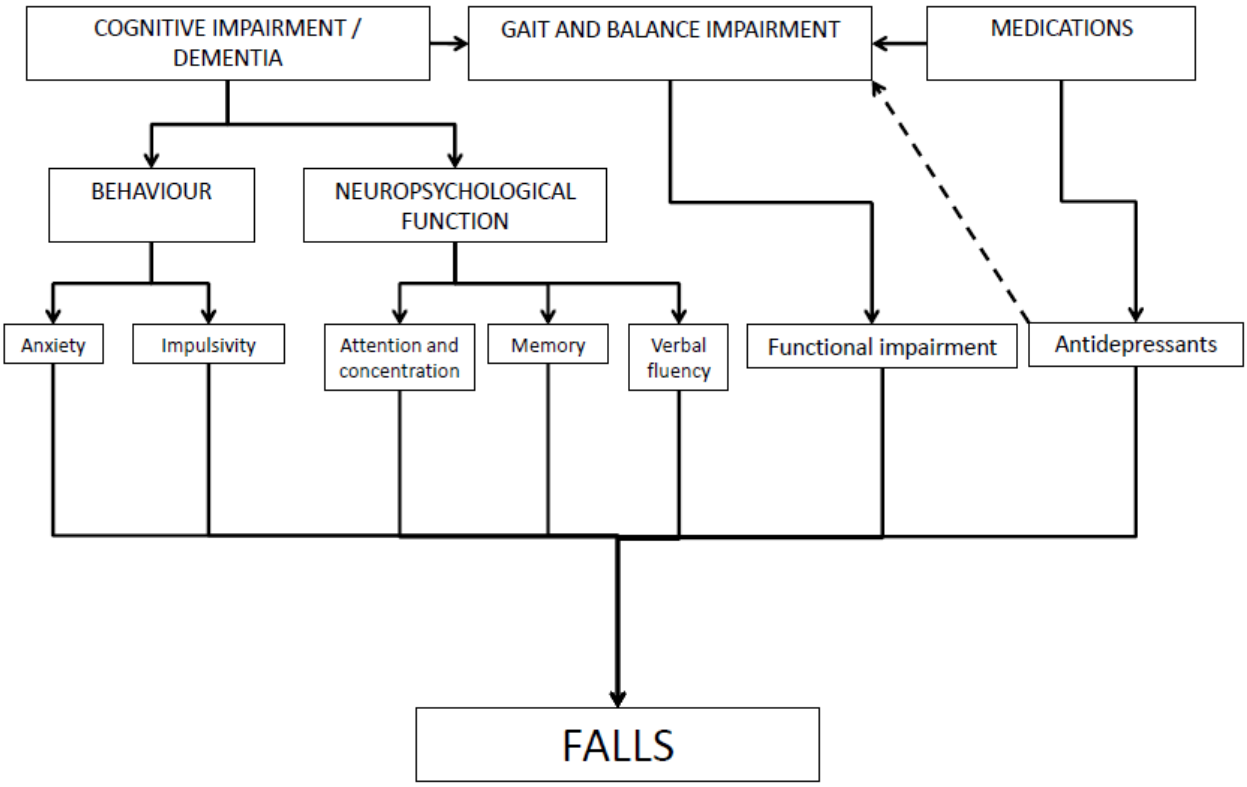
Unlike one study (Holtzer et al., 2007), this study found that those with worse memory were more likely to fall. Interestingly, none of the individual memory questions from the ACE-R identified significant differences, but the overall score distinguished between fallers and non-

fallers. One study found working memory to be associated with increased falls risk (Anstey et al., 2009) but in a population without dementia. Forgetting safety measures such as using a walking aid or waiting for help from others may increase falls risk. Finally although language was not different, verbal fluency was significantly worse in fallers. It has been suggested that verbal fluency is not simply a measure of language but also requires semantic memory and executive function (Mathuranath et al., 2000). The verbal fluency test requires production of appropriate words in a time limited context and this may be more appropriate than other language tests to the proposed mechanism for falls risk such as asking and describing help needed to care staff in a busy environment.

8.6 A theoretical framework to explain falls risk in older adults with cognitive impairment

The detailed study informed the development of a theoretical framework to explain falls risk in older people with cognitive impairment living in residential care. This framework is displayed in Figure 8.1. On the basis of this current study, falls risk is increased by a combination of gait and balance impairment, medication, particularly antidepressant use, impulsive behaviour, anxiety, and deficits in the cognitive domains of attention and concentration, memory and verbal fluency. This framework can be used to develop targeted interventions to prevent falls in this population.

Figure 8.1 Theoretical framework to explain falls risk in older adults with cognitive impairment



8.7 Possible interventions to address risk factors identified

To date there is limited evidence to support interventions to prevent falls in older people living in residential care facilities (Cameron et al., 2010). There is no evidence from planned analysis of randomised controlled trails for falls prevention in people with cognitive impairment. This may be in part due to the relatively simplistic unidimensional approach taken to date. Complex problems can require complex solutions and it is likely that successful intervention strategies to prevent falls in this setting will be individualised and multidimensional involving carers, the environment and the resident. Each of the risk factors illustrated in the theoretical framework will be discussed in the context of possible interventions.

8.7.1 Cognitive impairment / dementia

Given that in the detailed study each point higher in ACE-R corresponded to a 2% decreased risk of falling (0.98 [95%CI=0.96-1.00]) and in the screening study falls risk increased by 5% with every 1 point drop in the MMSE (0.95 95%CI 0.92-0.99), any intervention that prevents cognitive decline has the potential to be beneficial. Most residential care dwellers in this study population had some evidence of cognitive impairment. In the screening study, almost 90% of the participants had MMSE<24. However, a specific dementia diagnosis was only available for 36% of those with cognitive impairment and only 4% of the participants were prescribed drugs for dementia. Dementia screening and prevention of decline with appropriate medical interventions may be useful in minimising increases in falls risk over time. In fact, a recent case control study suggested that people with AD who used acetylcholinesterase inhibitors had a reduced risk of hip fracture (Tamimi et al., 2012).

8.7.2 Gait and balance impairments

The role of exercise in addressing gait and balance impairments in this population is unclear. Both the Cochrane review and a meta-analysis on exercise to prevent falls found no evidence that exercise is effective in this population (Cameron et al., 2010, Sherrington et al., 2008). There are several reasons for this. It may be that the cognitive impairment limits the ability to actively participate in exercise programmes (i.e. follow instructions) although the trial carried out by Shaw and colleagues found that participants were able to do the exercise (Shaw et al., 2003). Very frail groups such as those living in residential care may have a physiological ceiling to the possibility of improvement of strength, gait and balance with exercise. Considering the non-linear patterns where those with the worst function are at lower risk than those with moderate abilities (Lord et al., 2003a), eliciting small improvements in function without adequate improvements in postural stability may in fact increase falls risk. Finally, to maximise the reduction in falls through exercise, programmes must include highly challenging balance training specified as "exercise reducing the base of support or moving the centre of gravity while reducing reliance on support from the upper limbs" and have a duration of at least 6 months (Sherrington et al., 2008). Highly challenging balance training may be daunting to conduct with cognitively impaired older people. Difficulty following instructions while doing exercise in challenging positions could increase the risk of actually falling while doing the exercises. One of the possible reasons that exercise has not so far been successful is that none of the programmes have achieved the required intensity and duration of exercise. A trial including highly challenging balance training but with, greater supervision and higher staff to participant ratios to ensure safety over a 6-month period could address this hypothesis.

8.7.3 Functional impairments

Functional impairment as a result of physical disability may improve with exercise training. However, function may also be impaired due to cognitive difficulties. This is highlighted by the fact that when the Barthel was broken down into sections, differences between fallers and non-fallers were in domains relating to personal care rather than mobility. Task simplification involves the assessment for preserved cognitive functions and implementation of strategies to address safety and behavioural risk by focusing on meaningful functional activities (Bieber and Keller, 2005). Identifying those who struggle with personal care activities due to cognitive impairment and implementing this approach to maximise independence may result in improvements in function and behaviour (Wells et al., 2000) resulting in lower falls risk.

8.7.4 Medications

This study suggests that medication review and evidence based prescribing should be a key intervention for this population. Managing falls risk related to antidepressant use is a controversial topic. Since depression is associated with falls risk, withdrawing antidepressants risks increasing depressive symptoms which in turn increases fall risk. However, it may be the case that depression is not routinely reassessed in older people with dementia living in residential care and it is known that depression is common in early-moderate dementia and symptoms may reduce later with the progression of the disease (Reifler et al., 1982). Therefore antidepressants may not be indicated throughout the course of the dementing illness and regular medication and mood review is required.

8.7.5 Anxiety

Since it is not entirely clear how anxiety impacts on falls risk, it is difficult to ascertain what interventions may be effective. In any future intervention, it would be important to identify

anxiety and look into the underlying causes and treat as appropriate. This may include treatment of undiagnosed pain, appropriate activity to address boredom, comfort and company for loneliness. Dementia care mapping, is an intervention that includes observation of an individual to identify the root causes of dementia related behaviours and addressing these problems directly. There is some evidence that this technique improves falls outcomes (Chenoweth et al., 2009). Exercise is known to have beneficial effects on anxiety (Long and Stavel, 1995) and may be a useful intervention.

8.7.6 Impulsivity

There are few interventions described to address impulsivity and fewer to address falls related impulsive behaviours. There are several ways in which this risk factor could be addressed. Detection of impulsive behaviours using the FIBS and putting into place individualised plans to minimise the impact of such behaviours may be one approach. Examples include ensuring a walking frame is always within easy reach or placing commonly required objects (newspaper or remote control) close by. Some cases of highly impulsive behaviour, especially those on the background of very poor postural stability may require increased supervision. This may involve moving closer to the nursing station, intentional rounding or the use of movement sensors to alert staff to any attempts to move.

It may be possible to use exercise training to address issues of impulsivity. In certain individuals with poor balance, even a slight improvement in muscle strength and balance could improve postural stability to the extent that impulsive behaviours result in fewer falls. On the same note, it may be possible with the correct frequency and duration of training to improve safety of transfers and use of walking aids with simple task and context specific

practice. This is particularly pertinent considering the proportion of falls occurring during transfers (Table 4.16).

8.7.7 Neuropsychological function

The importance of managing cognitive decline through correct clinical diagnosis and management may be the only intervention that can directly affect the cause of neuropsychological dysfunction. However these specific impairments should be considered when delivering other interventions

8.7.7.1 Attention and concentration

Where there are impairments in attention and orientation, complex instructions should be avoided, as should activities that require divided attention (such as dual tasks) and intense concentration. In the context of providing exercise, verbal instructions should be minimised and should ideally contain only one piece of information. Verbal instructions should be complemented by physical demonstration and regular prompts provided to ensure continuing attention. Identifying those with poor attention and concentration and ensuring care plans provide more regular monitoring and prompting as suggested for impulsive behaviours may also be useful.

8.7.7.2 Memory

Interventions to compensate for memory impairment such as regular verbal or visual prompts may be the only option available. This could be targeted to specific high risk activities and within exercise interventions. Any information or instructions given to those with memory problems should be delivered in simple small chunks.

8.7.7.3 Verbal fluency

Identifying those with poor verbal fluency could prompt simplification of communication methods. Communication using symbols with a simple selection to choose from may be an alternative to relying on verbal transactions alone.

8.8 Limitations to this study

There were several limitations to this study. The limitations mostly involved the study population and the test measures used. Many of the limitations have been discussed in the individual chapters.

One of the main difficulties of this study was recruitment. Many residents and personal consultees did not wish to take part in the research. Participation in the smaller study which required detailed data collection was particularly affected by this and consultees acting on behalf of those without capacity were more likely to decline participation than residents who had capacity. It is difficult to know exactly why it was so difficult to recruit to a study which did not involve an intervention or any particularly invasive tests. It may be that the lengthy information sheets which must explicitly state all risks associated with taking part however small, put off participation. Most personal consultees warned of the risk that their relative could fall (during the balance tests) taking part in a research study that would not directly benefit them, would understandably prefer to take the safer option. The screening study which did not pose such a risk and did not require participants to be disturbed, recruited twice as many participants and while providing less detail, increased the statistical power of the study to confirm particular domains were associated with increased falls risk. The difficulty in recruitment limits the generalisability of the findings. Those who consent to participate in research studies could be significantly different to those who don't. Although, this is not possible to test, in this study, compared to those who agreed to the detailed study, those who only took part in the screening study were significantly more functionally impaired. This suggests that physical, cognitive and personality attributes may have influenced participation

in this study and the data presented here only generalisable to residents similar to those who took part.

The detailed study also excluded participants who would not be capable of undertaking the baseline tests and therefore the findings cannot be generalised those with severe dementia. External validation is required to confirm the findings in other populations.

The other main limitation was the tests used. The initial reliability testing identified that some of the tests had poor reliability (Table 2.4). Interestingly these were also the tests that did not differ between fallers and non-fallers (Melbourne edge test, hand reaction times and proprioception). Measuring performance in people with cognitive impairment may be less reliable than in a cognitively intact population as ability to follow commands, motivation and cognitive performance may fluctuate over periods of time (Hultsch et al., 2000). This problem would be inherent using any testing method and considering this, most of the tests had adequate levels of variability and reliability. It is not possible to say whether poor reliability limited these tests' ability to discriminate between fallers and non-fallers as there were few other feasible alternatives.

A significant majority of the study participants were unable to perform some of the tests (Table 4.3). Most of the participants could not stand with arms crossed and therefore qualify for the 5x sit to stand test neither were most able to stand unsupported for 30 seconds on foam to measure sway. Both these tests are high level tests of physical function and it is unsurprising that in this frail population, these tests could not be performed. However, they were included so that it was possible to differentiate those with the very highest physical performance from those with lower levels of function. The management of missing data by

allocating those who were unable to do the test with a score 3 standard deviations below the mean meant that participants from lowest to highest performance could be compared. In fact there was a significant difference between fallers and non-fallers on measures of postural sway standing on foam (Table 4.23). One fifth of the participants could not understand how to do the hand reaction time test or the trail making test. Considering that all participants taking part were cognitively impaired, that in the worst cases, four fifths could do the tests would suggest they were practical to undertake in this population.

Many of the tests selected to measure cognition demonstrated serious floor effects with mean scores well below aged matched normal values (Table 8.1). This may explain why none of these tests identified differences between fallers and non-fallers. The ACE-R which was less challenging than tests such as the logical memory story and Boston naming test was better able to identify differences as a larger range of scores with a normal distribution was produced by the cohort.

There are some specific methodological limitations around the analysis of falls outcomes. The decision to exclude those who had <4 months follow up without having fallen could have influenced results. Follow-up time of 6 months was half that used in standard prospective fall risk studies. The 6 month period was chosen as such a frail population could change substantially in one year rendering baseline measures less useful for predicting falls. Considering follow up was short, loss of >75% follow up may not be sufficient to determine true status as a faller. Those who had fallen and were subsequently lost to follow up were included as the loss to follow up was often the consequence of the fall. There may have been more appropriate ways to address this statistically but the numbers excluded for these reasons were small; 14 (5%) and 1 (0.9%) for the screening and detailed studies respectively.

It could also be argued that calcium and vitamin D medication should have remained in the model used to develop the screening tool. It is difficult to understand how taking these medications could be a cause of falls and not a marker of previous falls (resulting in the prescription). A screening tool incorporating this used in different care homes, where prescription of calcium and vitamin D is not routinely provided for fallers, may be less effective than using previous falls as a risk factor.

8.9 Future work

The CaHFRis screening tool (chapter 3) the PAM-RC (chapter 5) and FIBs (chapter 6) require external validation.

The overarching aim of this study was to comprehensively identify important risk factors for falls in older people with cognitive impairment living in residential care in order to develop a targeted intervention to be tested in future research. Therefore the first step is to conduct pilot studies to determine the feasibility, acceptability and clinical efficacy of interventions addressing the risk factors identified in this study. Successful pilot studies could lead to larger multi-centre trials powered to detect differences in falls taking into account cluster randomisation which would be required in this population. A fully powered trial resulting in reductions in falls would ultimately lead to research on implementation strategies in order to ensure effective interventions are incorporated into routine clinical practice.

8.10 Conclusion

The objectives of this study were met; baseline measures were collected on 240 care home dwellers who were prospectively followed up for 6 months to determine faller status. A physical activity questionnaire (PAM-RC) and impulsivity questionnaire (FIBS) were developed and validated and a further test, the perceived reach test designed and used in the study. Data was analysed using univariate and multivariate analysis. Seven significant and independent predictors of falls were identified in the large screening study and used to form the CaHFRiS screening tool. A theoretical framework was developed to explain falls risk in older adults with cognitive impairment living in residential care based on the findings of both the large screening and small detailed studies. This framework has been used to design targeted multifactorial interventions to prevent falls in this population.

The research set out to determine important falls risk factors in older people with cognitive impairment living in residential care and found that risk factors included use of antidepressants, hypnotic/axiolyitc drugs, requiring a walking frame, previous falls, impaired balance, impulsivity and anxiety and impaired cognition in particular attention and concentration. The results support the hypothesis that falls risk is increased by a combination of impaired gait and balance, cognitive dysfunction and dementia related behaviours. However, the hypothesis should also include the importance of psychotropic medication use.

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10 Appendix A

10.1 Table of falls prevention intervention research for community dwellers (see chapter 1)

Table 10.1 Falls prevention interventions for community dwelling populations

Author (year)	N	Intervention	Inclusion/ exclusion (CI)	Cognitive status	Significant effect on falls
Assantachai (2002)	1043	Education leaflet, free access to geriatric clinic for CGA	Exclusion criteria not presented	Mean Thai Mental status examination =23 /30	↓
Ballard (2004)	40	Exercise (aerobic, strength and balance) for 15/52 (control and intervention had home safety intervention).	Not excluded		
Barnett (2003)	163	Exercise (strength, balance, coordination, stretching) 52/52	Cognitive impairment (not defined) excluded	Not measured or presented	↓
Bischoff-Ferrari (2006)	445	Vitamin D 700IU and calcium 500mg	Not excluded	Not measured or presented	↓in women
Blalock (2010)	186	Face to face medication review in those taking culprit medications	Excluded if ≥3 errors on 6 item test derived from MMSE	Not presented	→
Buchner (1997)	105	Exercise (either strength, endurance or strength and endurance). 24-26/52	Not explicitly excluded	Not measured or presented	↓
Bunout (2005)	298	Exercise (resistance, functional, weight-bearing, walking) 52/52	Excluded if MMSE <20	Not presented	→
Campbell (1997)	233	Exercise (taught by physiotherapist, home exercise: resistance, balance and walking Otago exercise programme (OEP)) 52/52	Excluded if cognitive impairment defined as MTS <7/10	Not presented	↓
Campbell (1999)	93	Factorial design (psychotropic mediation	Excluded if cognitive	Not measured or	↓in psychotropic

Author (year)	N	Intervention	Inclusion/ exclusion (CI)	Cognitive status	Significant effect on falls
		users) 1. Withdrawal from psychotropic medication 2. Exercise (OEP) 3. 1 and 2 4. Control	impairment defined as MTS <7/10	presented	withdrawal group
Campbell (2005)	391	Factorial design (those with severe visual impairment) 1. Exercise (OEP) 2. Home safety assessment 3. 1 and 2 4. Control	Excluded if couldn't understand the trial requirements	Not measured or presented	↓in home safety group
Carpenter (1990)	539	Visit from trained volunteer and referral to GP if increased disability score	Not explicitly excluded	Not presented	↓
Carter (2002)	93	Exercise (strength and stretching)	Not explicitly excluded	MMSE measured but not presented	→
Ciaschini (2009)	201	Nurse assessment and referral for medication review, physiotherapy and/or occupational therapy	No exclusion criteria	4-11% were diagnosed with confusion	↑
Clemson (2004)	310	Stepping on programme (education, self efficacy and exercise)	Excluded if dementia defined as SPMSQ >3 errors	Mean SPMSQ 9.8	↓
Close (1999)	397	Comprehensive geriatric assessment and appropriate referral and OT assessment	Excluded if AMT <7	Mean AMT 8.4-8.6 34% had cognitive impairment	↓
Coleman (1999)	169	Clinics, reducing polypharmacy, support and self management groups	Excluded if moderate to severe dementia	Not presented	→
Conroy (2010)	364	Day hospital delivered strength and balance training, medication review and home hazard assessment	Not explicitly excluded	Not measured / presented	→
Cumming (1999)	530	OT home visit and supervision of	Excluded if CI and not	Not presented	↓ (in those with previous

Author (year)	N	Intervention	Inclusion/ exclusion (CI)	Cognitive status	Significant effect on falls
		modification	living with a carer		falls)
Cumming (2007)	616	Vision test and eye exam, provision of walking aids and mobility training	Excluded if CI and not living with a carer	16-18% had MMSE <24	↑
Davison (2005)	313	Multi-factorial assessment and intervention	Excluded if MMSE <24	Mean MMSE 28-29	↓
Day (2002)	1107	Factorial trial 1. Exercise 2. Vision 3. Home hazard removal 4. 1 and 2 5. 1 and 3 6. 2 and 3 7. 1, 2 and 3 8. Control	Excluded if SPMSQ >4 errors	Not presented	↓exercise or if exercise involved in the combination
De Vries (2010)	217	Assessment of falls risk with medication review, vitamin D (if levels are low), physiotherapy home visits, occupational therapy and vision assessment	Excluded if MMSE <24	Median MMSE 28	→
Dhesi (2004)	139	Vitamin D (single injection)	Excluded if AMT <7	Mean AMT 9.4-9.5	↓
Dukas (2004)	378	Vitamin (daily dose for 26/52)	Excluded if dementia	Not measured or presented	↓only if calcium intake of >512 mmg/d
Elley (2008)	312	Home assessment by nurse and referral	Excluded if dementia, unable to understand the process or AMT <7	No presented	→
Fabacher (1994)	254	Home visit to screen with targeted intervention	Excluded if dementia	3.4% MMSE ≤25	→
Foss (2006)	239	Cataract surgery	Excluded if memory problems	Mean MMSE 27	→
Freiberger (2012)	280	1. Strength and balance exercise 2. Strength, balance and endurance exercise 3. Strength, balance, endurance and	Excluded if cognitive impairment defined as score <25 on DSST	DSST 39-42	→

Author (year)	N	Intervention	Inclusion/ exclusion (CI)	Cognitive status	Significant effect on falls
		education All 2 hours per week for 16/52			
Gallagher (1996)	100	Comprehensive risk assessment and feedback on risks, motivational video and booklet	No specific exclusion but "health problems that make it difficult to function"	Not presented	→
Grant (2005)	5292	1. Daily vitamin D 2. Daily calcium 3. Daily vitamin D and calcium 4. Control	Excluded if MTS ≤6	Not presented	→
Gray-Donald (1995)	50	High energy nutritional supplements	Included if judged orientated to time and place	Not presented	↓
Green (2002)	170	Community physiotherapy for stroke survivors (>1 year post stroke)	Excluded dementia defined as AMT <7	Not presented	→
Greenspan (2005)	373	1. HRT 2. HRT and Alendronate 3. Alendronate 4. Control	Not explicitly excluded	Mean MMSE 29	→
Haines (2009)	53	Home exercise using DVD with encouragement	Excluded if AMT <6	Not measured / presented	→
Haran (2010)	606	Replace bifocals with single lens glasses	Excluded if MMSE <24	Mean MMSE 29.5-29.6	↓outdoor falls in those who took part in regular outdoor activity
Harwood (2004)	150	1. Single dose vitamin D 2. Single dose vitamin D and calcium 3. Daily dose of vitamin D and calcium 4. Control	Excluded if AMT <7	Not presented	↓for vitamin D
Harwood (2005)	306	Expedited cataract surgery	Excluded if memory problems	Median MMSE 27	↓falls and #
Hauer (2001)	57	Exercise (ambulatory training of strength, function and balance) 3x week for 12/52	Excluded if severe cognitive impairment	Mean MMSE 27	→

Author (year)	N	Intervention	Inclusion/ exclusion (CI)	Cognitive status	Significant effect on falls
Helbostad (2004)	77	1. Exercise (group strength, function and balance) 2x week for 12/52 with non progressive home exercises 2. Non progressive home exercises	Excluded if MMSE<22	5% had CI	→
Hendriks (2008)	333	Multi-factorial intervention on those attending ED or GP with falls (occupational therapy and medical assessment and recommendations or referral)	Excluded in AMT <4/4		→
Hogan (2001)	163	Risk assessment, case conference, recommendations and instructions for exercise	Inclusion if "mentally intact"	Mean MMSE 28	→ (longer time between falls)
Hornbrook (1994)	3182	Home visit and safety information and falls prevention advice	Excluded if not "able to give consent"	Not measured / presented	→
Huang (2004)	120	Home visit and education on risk factors	Included if "cognitively intact"	Not presented / measured	→
Huang (2005)	141	Gerontological nurse review while in hospital post #hip and for 3/12 after discharge	Excluded if CI	Not measured / presented	→
Jitapunkul (1998)	160	Questionnaire to patients and carers and help provided if indicated	No exclusion criteria stated	Not measured / presented	→
Kenny (2001)	175	Cardiac pacemaker for cardioinhibitory carotid sinus syndrome	Included if MMSE >23	Not measured / presented	→
Kingston (2001)	109	Health visitor intervention: advice on diet and exercise, education about risk factors	Excluded if could not complete tests due to CI	Not measured / presented	→
Korpelainen (2006)	160	Physiotherapy led exercise programme (1 hour session (?each week) for 6 months with home exercise programme for 20 mins each day. Balance and functional strength exercises.	Excluded if severe CI	Not measured / presented	→ (fewer #)
Lannin (2007)	10	Occupational therapy pre discharge visit	Excluded if CI defined as	Not measured /	→

Author (year)	N	Intervention	Inclusion/ exclusion (CI)	Cognitive status	Significant effect on falls
			<4 on SPMSQ	presented	
Latham (2003)	243	1. Resistance exercise (3 times week for 10 weeks) 2. Exercise control 3. Vitamin D (single oral dose) 4. Vitamin D placebo	Excluded if CI defined as MMSE <20	Mean MMSE 27-28	→
Li (2005)	256	Tai chi 3x week for 26/52	Excluded if CI defined by SPMSQ	Not measured / presented	↓
Lightbody (2002)	348	Multi-factorial assessment by nurse and referral to services, advice and education	Excluded if unable to consent	15% of the intervention group had cognitive problems	→
Lin (2007)	150	1. Home exercise (flexibility, balance and strength training 60 mins 3x a week) 2.Home safety assessment and modification 3.Education	Not explicitly excluded	30% were cognitively impaired	→
Liu-Ambrose (2004)	104	1. Resistance training for 25/52 2. Agility training for 25/52 3. Control	Excluded if MMSE≤23	Mean MMSE 28	→
Liu-Ambrose (2008)	74	Otago exercise programme (home balance and strength exercise 3x week, walking 2x week)	Excluded if MMSE <24	Mean MMSE28	↓ (if outliers are removed and adjusted for other significant variables)
Logghe (2009)	269	Tai chi 1 hour 2x week for 13/52	Excluded if progressive disorder or Alzheimer's disease	Not measured / presented	→
Lord (1995)	194	Group exercise (warm up, conditioning, strength and relaxation) 2x week for 52/52	Not excluded for CI	Not measured / presented	→
Lord (2003)	551	1. Group exercise (strength, balance, function) 2x week for 52/52 2. Control exercise (seated) 2x week for 52/52	Excluded if MMSE <20	Not presented	↓

Author (year)	N	Intervention	Inclusion/ exclusion (CI)	Cognitive status	Significant effect on falls
		3. Control			
Lord (2005)	620	Risk factor assessment using the physiological profile assessment then intervention to address risk factors including exercise, vision and sensation	Excluded if CI defined as SPMSQ <7	Not presented	→
Luukinen (2007)	486	Nurse assessment and plan devised by physiotherapist and OT. Intervention included home or group exercises, walking and self care exercises	Not excluded	Mean MMSE 23-24	→
Mahoney (2007)	349	Falls risk assessment by nurse or physiotherapist referrals including exercise (advice to walk 4-5x week and standing balance exercise 2-3x week)	Excluded if unable to give consent and no caregiver	Mean MMSE 27	→ On subgroup analysis fewer falls following intervention in those with MMSE<27
McKiernan (2005)	113	Yatrax walker in winter to provide non slip sole for outside	Excluded if "unable to discern correct conditions to wear the walker"	Not measured / presented	↓
McMurdo (1997)	118	Weightbearing exercises and advice 3xweek for 30/52 a year for 2 years	Not explicitly excluded	Not measured / presented	↓after 12-18/12
Means (2005)	338	Exercise (stretching, balance, strength and coordination in group) 90mins 3x week 6/52	Excluded if CI defined as MMSE<24	Not presented	↓
Meredith (2002)	317	Medication review	Not explicitly excluded	Mean MMSE 24	→
Morgan (2004)	294	Exercise (low intensity seated and standing for strength, balance, flexibility and gait) for 45mins 3x week for 8 weeks	Excluded if MMSE <23	Not presented	→ Fewer falls in group with low physical function at baseline
Newbury (2001)	100	Nurse assessment, problems identified and referred to GP	Excluded for dementia (unable to consent)	77-89% "normal" on MMSE on follow up	→
Nikolaus (2003)	360	Comprehensive geriatric assessment, home visit, taught correct use of mobility aid	Excluded if severe cognitive decline	Mean MMSE 26	↓

Author (year)	N	Intervention	Inclusion/ exclusion (CI)	Cognitive status	Significant effect on falls
Nitz (2004)	73	Exercise (balance training in group for 1 hour a week for 10/52) Control group – gentle exercise	Not explicitly excluded	Not measured / presented	↓
Pardessus (2002)	60	Home visit, assessment of function and advice / modification	Excluded if MMSE <24	Not measured / presented	→
Pereira (1998)	229	Walking groups (2x week with 8/52 supervision aiming for 7 miles a week)	Not explicitly excluded	Not measured / presented	→
Pfeifer (2000)	148	Vitamin D and calcium	Not excluded	Not measured / presented	↓
Pighills (2011)	238	1. Occupational therapy intervention 2. Trained assessor intervention 3. Control	Not excluded	Not measured / presented	↓ (in occupational therapy group only)
Pit (2007)	849	Education for GPs, financial incentives for medication review	Excluded if confused and not accompanied by caregiver	Not presented / measured	↓ ↓fall related injuries
Porthouse (2005)	3314	Vitamin D and education session	Excluded if CI	Not measured / presented	→
Prince (2008)	302	Vitamin D and calcium	Excluded if MMSE <24	Mean MMSE 28	↓ (if adjusted for height)
Reinsch (1992)	230	1. Exercise (stretching, strength and balance 1 hour 3x week for 52/52) 2. Cognitive behavioural (education, relaxation and video games to help reaction times 1 hour 3x week 52/52) 3. Cognitive behavioural and exercise (option 2 once a week and option 1 twice a week for 52/52) 4. Discussion group (1 hour, 1x week 52/52)	Not excluded	Not measured	→
Robertson (2001)	240	Exercise (Otago exercise programme; balance strength and walking, 3x week for 1 year) taught by trained nurse	Excluded if "not able to understand the trial requirements"	Not measured / presented	↓

Author (year)	N	Intervention	Inclusion/ exclusion (CI)	Cognitive status	Significant effect on falls
Robson (2003)	660	Two sessions run by volunteers. First session given advice on falls risk and home assessment to undertake. Second session given exercise video (Tai chi for balance and strength) and asked to exercises 20 minutes a day or attend exercise group for 45 mins 3x week	Excluded if "health problems made it difficult to function).	Not measured / presented	↓
Rubenstein (2000)	59	Exercise (strength, endurance and balance) group sessions lasting 90 minutes 3 x week for 12/52	Excluded if dementia	Mental status score ranged 3.1-3.6	→ (accounting for ↑activity, ↓falls)
Rubenstein (2007)	792	Structured risk and needs assessment and recommendation for treatment targeting 5 geriatric conditions (including falls)	Included if "having possible memory problems"	20% had cognitive impairment Mental status score (0-26) range 4.6-5.0	→
Russell (2010)	712	Multi-factorial assessment and referral to physiotherapy, occupational therapy, podiatry, dietician or falls clinic	Excluded if AMT <7, "unable to follow instructions without caregiver"	Mean abbreviated mental test score = 30	→
Sanders (2010)	2256	Vitamin D (single dose injection)	Excluded if could not provide informed consent or information on falls	Not measured / presented	↑
Sato (1999)	86	Vitamin D	Not excluded	Not measured / presented	→
Schrijnemaekers (1995)	222	Comprehensive geriatric assessment and advice to GP	Not excluded	35-44% AMT ≤8/10	→
Shigematsu (2008)	68	1. Square stepping exercise, group sessions 2x week 2. Supervised walking	Not excluded	Not measured / presented	→
Shumway-Cook (2007)	453	Exercise in groups, 1 hour 3x week, 12/12, 6 falls prevention classes, falls assessment with	Excluded if ≥ 5 errors on SPMSQ	Not measured / presented	→

Author (year)	N	Intervention	Inclusion/ exclusion (CI)	Cognitive status	Significant effect on falls
		summary to GP			
Skelton (2005)	100	Exercise (strength, balance, flexibility, endurance, floorwork) in group for 1 hour 1x week and at home 30mins 2x week for 36/52	Excluded if "significant cognitive impairment"	Not measured / presented	↓
Smith (2007)	9440	Vitamin D (single dose injection)	Not excluded	Not measured / presented	→
Spice (2009)	516	1. Multi-disciplinary day hospital assessment by physician, physiotherapist, occupational therapist 2. Health visitor / practice nurse assessment and referral 3. Usual care	Excluded if AMT <7	Mean AMT = 9	↓ (intervention 1)
Spink (2011)	305	Podiatry; orthoses, footwear, foot exercises, education and podiatry	Included if cognitively intact SPMSQ ≥7	Not measured / presented	↓
Steadman (2003)	198	1. Physiotherapy and balance training exercises, 45 mins 2x week for 6/52 2. Physiotherapy	Excluded if "severe cognitive impairment"	Not measured / presented	→
Steinberg (2000)	252	1. Exercise once a month for 17/12 2. 1 and home safety assessment 3. 1 and 2 and clinical assessment	Included if "capacity to understand and comply with study"	Not measured / presented	→ (↓slips and trips)
Stevens (2001)	1737	Nurse home visit assessment with home hazard assessment, instillation of safety devices and education	Inclusion if "cognitively intact"	Not measured / presented	→
Suzuki (2004)	52	Exercise (group and home based) 10 classes + 30 mins 3x week for 6/12	Not excluded	Not measured / presented	↓
Taylor (2012)	684	1. Tai chi 1x week for 20/52 2. Tai chi 2x week for 20/52 3. Low intensity exercise	Excluded if MMSE <23	Not measured / presented	→
Tinetti (1994)	301	Multi-factorial assessment and targeted intervention	Excluded if MMSE <20	20-22% of MMSE's <25	↓

Author (year)	N	Intervention	Inclusion/ exclusion (CI)	Cognitive status	Significant effect on falls
Trivedi (2003)	2686	Vitamin D	Not excluded	Not measured / presented	→
Van Haastregt (2000)	316	Five home visits from nurse for advice and referrals	Not excluded	Not measured / presented	→
Van Rossum (1993)	580	Four home visits from nurse for advice and referrals	Not excluded	Not measured / presented	→
Vetter (1992)	674	Health visitor home visits at least yearly (for 4 years) advice and physiotherapy classes if needed	No exclusion criteria	Not measured / presented	→
Vind (2009)	392	Identification of risk factors and individual treatment	Excluded if dementia	Not presented	→
Voukelatos (2007)	702	Tai chi for 16/52	Excluded if dementia	Not measured / presented	→ (but ↑ time to first fall)
Wager (1994)	1559	1. Nurse interview and development of tailored intervention 2. Chronic disease prevention nurse intervention 3. Control	Included if "independent"	Not measured / presented	↓ (in group 1)
Weerdesteyn (2006)	113	Exercise (low intensity balance, gait, training in fall techniques) 2x week for 5/52	Excluded if "pathologies associated with increased risk of falls"	Not measured / presented	↓
Whitehead (2003)	140	Assessment and information given to GP to act upon	Excluded if MMSE <25	Not measured / presented	→
Wolf (1996)	200	1. Tai chi 2x week for 15/52 2. Computerised balance training 1x week 15/52 3. Control	Excluded if severe CI	Not measured or presented	↓
Wolf (2003)	311	1. Intense Tai chi 2x week for 48/52 2. Wellness education 48/52	Excluded if MMSE<24	Not presented	→
Woo (2007)	180	1. Tai chi 3x week for 12/12	Excluded if dementia	Not measured /	→

Author (year)	N	Intervention	Inclusion/ exclusion (CI)	Cognitive status	Significant effect on falls
		2. Resistance training 3x week for 12/12 3. Control		presented	
Wyman (2007)	272	Multifactorial intervention including risk assessment, night lights, individualised risk reduction strategies	Included if "mentally intact" defined as MMSE >23	Mean MMSE 28.5	

SPMSQ = short portable mental status questionnaire, MMSE = mini mental status examination, AMT = abbreviated mental test
MTS = Mental Test Score, DSST digit symbol substitution test

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10.2 Table of falls prevention intervention research in care home dwellers

Table 10.2 Falls prevention interventions in care home dwellers

Author	N	Intervention	Inclusion / exclusion criteria CI	Population details	Significant effect on falls
Becker (2003)	981	Multi-factorial intervention consisting of balance and resistance training, 2x week for 75 minutes for 12/12, walking aids and environmental adaptation, hip protectors and staff/resident education	No exclusion criteria	74% female Mean age 83.5-84.3 Rates of CI 44-73% between sites	On falls IRR 0.55 (95%CI 0.41-0.73) On fallers RR 0.75 (95%CI 0.57-0.98)
Broe (2007)	124	Vitamin D 1. 200 IU 2. 400IU 3. 600IU 4. 800IU 5. Placebo	Not excluded for CI	73% female Mean age 89 CI not measured or presented	On falls IRR 0.28 (95%CI 0.11-0.75) for 800IU only
Chapuy (2002)	610	800IU of vitamin D and calcium	Not excluded for CI	100% female Mean age 85.2 CI not measured or presented	Not significant
Choi (2005)	68	Tai chi, 35mins, 3x week for 12/52	Excluded if severe dementia defined as MMSE <20	75% female Mean age 77.9 CI not presented	Not significant
Cox (2008)	5637	½ day staff training on falls and falls prevention	No exclusion criteria	77% female Mean age 85 CI not measured or presented	Not significant
Crotty (2004a)	110	Intervention on patients being discharged from hospital to care home. Pharmacist transition coordinator, medication management and review, case	Not excluded for CI	61% female Mean age 82.7 CI not measured or presented	Not significant

Author	N	Intervention	Inclusion / exclusion criteria CI	Population details	Significant effect on falls
		conferences with physicians and pharmacists			
Crotty (2004b)	715	Education intervention: pharmacist visited physician and provided home with education on withdrawal from psychotropic medication. One nurse from each home given 4x 2 hour education sessions.	Not excluded for CI	84% female Mean age 84.1 33-43% had diagnosis of dementia	Not significant
Dyer (2004)	196	Exercise (gait, balance, strength and flexibility) group or individually, 3x week, 40 mins, 3/12. Geriatrician screen. Occupational therapy assessment. Staff education.	Not excluded for CI	78% female Mean age 87 AMT 6.2-7.4	Not significant
Faber (2006)	278	1. Functional walking: 10 exercises (gait, balance and coordination) for 90 mins 1xweek for 4/52 and 2x week for 16/52. 2. In balance (Tai chi) 90 mins 1x week for 4/52 and 2x week for 16/52 3. Control	Excluded if poor cognition as judged by staff	79% female Mean age 84.9 Mean MMSE 25	Not significant
Flicker (2005)	693	Vitamin D (weekly or daily) + calcium	Not excluded for CI	95% female Mean age 83 41-45% not cognitively impaired (AMT8-10)	IRR 0.73 (95%CI 0.57-0.95)
Jensen (2002)	402	11/52 intervention Supervised exercises, medication review, modification of environmental hazards, supplying and repairing aids, hip protectors, staff education and post fall	Not excluded for CI	72% female Mean age 84 Median MMSE 18-20	RR 0.78 (95%CI 0.64-0.96)

Author	N	Intervention	Inclusion / exclusion criteria CI	Population details	Significant effect on falls
		problem solving			
Kerse (2004)	617	Risk management for those at high risk. Logo and tailored prevention strategies: removal of hazards, staff education, falls risk manual, falls coordinators, caregiver instructions, medication review, referral to physician, physiotherapy, optometrist and ENT.	Not excluded for CI	82% female Mean age 83 47-53% diagnosed with dementia	Increased falls IRR 1.34 (95%CI 1.06-1.72)
Kerse (2008)	682	Residents and the home set goals Physiotherapy and occupation therapy assist to achieve goals. Programme implemented by health care assistants	Included if able to engage in a conversation about a goal, remember the goal and participate in a programme Excluded if unable to communicate	74% female Mean age 84 Mean AMT 7.2	Not significant
Koczy (2011)	333	Intervention to reduce restraint use; education, technical aids as alternative (hip protectors, anti slip socks and sensory mats) and support.	Not excluded if CI	71-82% female 70% aged >80 Mean cognition score 10-11 (0=none – 16 severe)	Not significant
Lapane (2011)	3203 (yr1) 3538 (yr2)	Use of geriatric risk assessment medguide (GRAM) to trigger monitoring plans	Not excluded if CI	68-74% female 36-39% aged >85 20-29% severe CI	Not significant
Law (2006)	3717	Vitamin D 3 monthly	Not excluded if CI	76% female Mean age 85 CI not measured or presented	Not significant

Author	N	Intervention	Inclusion / exclusion criteria CI	Population details	Significant effect on falls
McMurdo (2000)	133	Exercise (supervised and seated) 30 minutes 2x week for 6/12. Falls risk assessment. Medication review. Optometrist. Review of lighting levels.	Excluded if MMSE <12	81% female Mean age 84 Mean MMSE 18-19	Not significant
Mulrow (1994)	194	Exercises (gait, balance, coordination, strength and flexibility delivered by physiotherapist) 3x week 30-45 minutes for 4/12.	Excluded if MMSE <50% or unable to follow 2 step command or assaultive behaviour	71% female Mean age 80	Not significant
Neyens (2009)	528	Multidisciplinary fortnightly conferences to discuss residents (at admission, after fall, on request, every 2 years). Medical assessment, medication review, occupational therapy environmental screen, tailored exercise programme and provision of aids.	Not excluded if CI	65-71% female Mean age 82 Mean MMSE 7.0-9.3	Not significant on intention to treat but if adjusted for unit and participant parameters IRR 0.64 (95%CI 0.43-0.96)
Nowalk (2001)	110	1. Exercise (strength, flexibility, endurance) 3x week 13-28/12 2. Tai chi and managing behaviour to modulate fear of falling. 13-28/12	Included if cognitively able to be tested and able to follow simple directions	86% female Mean age 85 Mean MMSE 25	Not significant
Patterson (2010)	334	Algorithm to determine appropriateness of prescription of medications and liaison with GP	Not excluded if CI	73-73% female Mean age 83 Mean MDS cognition scale 6-10 61-65% had severe CI	Not significant
Ray (1997)	499	Consultation service recommendations targeted to environmental hazards, medications, transfers, ambulation and use of a falls coordinator	Not excluded if CI	78% female Mean age 83 48-49% had “marked cognitive impairment”	Reduced falls by 19% (95%CICI 2-36%)
Rosendahl (2008)	191	Exercises (designed by physiotherapist	Included if MMSE≥10	73% female	Not significant

Author	N	Intervention	Inclusion / exclusion criteria CI	Population details	Significant effect on falls
		according to functional deficits)		Mean age 85 Mean MMSE 18	
Rubenstein (1990)	160	Post fall assessment (within 7/7 of the fall). Screening vision, blood pressure, footwear, balance and gait. Lab tests, cardiac monitoring, environmental hazard assessment and listing of recommendations.	Not excluded if CI	85% female Mean age 87 CI not measured or presented	Not significant
Sambrook (2012)	602	Sunlight exposure 5x week for 0.5-1 hour in morning	Not excluded if CI	71% female Mean age 86 52-66% MMSE <24	Not significant with intention to treat but very poor adherence If compare those with ≥50% adherence IRR 0.52 (95%CI 0.31-0.88)
Schnelle (2003)	190	Exercise (mobility and upper limb) and toileting programme 5x week for 8/12	Not excluded if CI	83% female Mean age 88 Mean MMSE 12-14	No significant reduction in fallers but falls reduced OR 0.46 SE=0.18.
Shaw (2003)	308	Multifactorial assessment and intervention protocol: Exercise provided by physiotherapy (gait , balance, strength, functional ability, flexibility). Medical assessment. Medication review. Cardiovascular interventions. Occupational therapy assessment.	Included if MMSE <24	80% female Mean age 84 Recruited because of CI but 79% came from care homes Mean MMSE 12-14	Not significant
Sihvonen (2004)	27	Exercises (balance training using visual biofeedback) 3x week 20-30 minutes, 4/52	Excluded if "dementia"	100% female Mean age 82 CI not measured or presented	Decreased falls rates IRR 0.40 (95%CI 0.17-0.91)

Author	N	Intervention	Inclusion / exclusion criteria CI	Population details	Significant effect on falls
Zermansky (2006)	661	Medication review undertaken by pharmacist with recommendations made to GP	Not excluded if CI	77% female Mean age 85 Mean SMMSE 13.1-13.8	No significant reduction in fallers but falls per person RR 0.59 (95%CI 0.49-.070)

SPMSQ = short portable mental status questionnaire, MMSE = mini mental status examination, AMT = abbreviated mental test
MTS = Mental Test Score, DSST digit symbol substitution test

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11 Appendix B: Participant information

Figure 11.1 Information sheet for participants with capacity
Version 4.
March 2009

King's College Hospital NHS
NHS Foundation Trust

Protocol reference number:
07/H0807/82

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INFORMATION ABOUT THE RESEARCH

Defining falls risk factors in older adults

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve.

- Part 1 tells you the purpose of this study and what will happen to you if you take part.
- Part 2 gives you more detailed information about the conduct of the study.

PART 1

What is the purpose of the research?
To find out why older people with memory problems are more likely to fall.

Why have I been invited to take part?
All residents living in this establishment will be invited to take part.

Do I have to take part?
No, you do not have to take part. If you agree to take part, you will then be asked to sign a consent form. Once you have signed the form, you can still stop taking part at any time and without giving a reason. This will not affect the standard of care you receive.

What will happen to me if I decide to take part?

1. If you decide to take part a researcher (Julie Whitney) will come to see you to carry out several assessments. These assessments are usually spread out over 3 sessions on different days and include:

Session 1
A set of memory tests taking around 45 minutes.
Session 2
Tests looking at your vision, muscle strength, walking, balance, blood pressure and a medical examination taking around 60 minutes.
Session 3
A further set of memory tests, some questions about your health and one balance test in total it takes 45-60 minutes.

2. Details of your medical history and medication use will be taken from care records and medical notes.

3. We will also ask if you would be willing to wear a small lightweight monitor attached to your leg to measure how much of the day you spend lying down, sitting or walking. We would ask you to wear this for up to 3 days.

4. After this we will then monitor you for 6 months to see whether you have any falls. You do not need to do anything from this point as your carers will record any falls you have and share this information with us.

You may not be able to carry out all of these assessments. We will only ask you to do what you are capable of doing.

What are the risks and possible disadvantages of taking part?
There is a very small chance of injury due to falls when carrying out the balance assessments. However, this is unlikely as assessments will be carried out by a qualified and experienced researcher and are consistent with current clinical practice.
There is a very small chance of discomfort caused by wearing the activity monitor. If this happens, the monitor can be removed immediately.

What are the possible benefits of taking part?
This study is unlikely to help you directly, but the information we get should help us to design treatment programmes to prevent falls in the future.
If we identify any new health problems during the research visits, with your agreement, we will contact your GP.

What if there is a problem?

In the case of any complaints you can telephone: 020 3299 3420. Please read part 2 for more details.

Will my taking part in the study be kept confidential?
We will follow ethical and legal practice and all information about you will be handled in confidence. Please read part 2 for details.

Defining falls risk factors in older adults

PART 2

What will happen if I don't want to carry on with the study?
Participation is voluntary and whether you decide to participate or not, it will not impact on your future health care.
If you decide to participate, you can change your mind at any time.

What if there is a problem?
Complaints
If you have a concern about any aspect of this study, you should ask to speak with the researchers who will do their best to answer your questions. **Telephone: 020 3299 3420.** If you remain unhappy and wish to complain formally, you can do this through the NHS Complaints Procedure. Details can be obtained from Kings College Hospital **Telephone: 020 3299 1760.**

Harm
In the event that something does go wrong and you are harmed during the research study there are no special compensation arrangements. If you are harmed and this is due to someone's negligence then you may have grounds for a legal action for compensation against Kings College Hospital but you may have to pay your legal costs. The normal National Health Service complaints mechanisms will still be available to you.

Will taking my part in the study be kept confidential?
All information which is collected during this research will be kept safely and nothing that would allow you to be identified personally will be published.
Your general practitioner will be informed of your participation in the study.

What will happen to the results of the study?
The results will be written up for publication in journals and presented at conferences and to participating care home. We will provide you with information on the results if you request it. You will not be identified in any publication or presentation.

Who is organising and funding the research?
The research will be organised by Julie Whitney at the Clinical Age Research Unit, Kings College Hospital. The research has been funded by the British Geriatrics Society / Dunhill Medical Trust fellowship scheme. The project will be supervised by Professor Jackson, a consultant at Kings College Hospital.

Who has reviewed the study?
All research in the NHS is looked at by an independent group of people, called a research ethics committee to protect you safety, rights, wellbeing and dignity. This study has been reviewed and given a favourable opinion by the Institute of psychiatry and South London and Maudsley research ethics committee.

You will be given a copy of this information sheet and a signed consent form to keep. Thank you for taking the time to read through this information sheet.

Figure 11.2 Consent form for participants with capacity
Version 2
January 2008

King's College Hospital NHS
NHS Foundation Trust

Clinical Age Research Unit
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Direct tel: 020 3299 3420
Direct fax: 020 3299 3441
Email: Julie.whitney@kch.nhs.uk

R&D Study Number: 07PM01
Patient Identification Number for this trial:

CONSENT FORM

Title of Project: Defining Falls Risk Factors in Older Adults with Cognitive Impairment

Name of Researcher: Julie Whitney

Participant please initial box

1. I have read the information sheet dated March 2009 (version 4) for the above study and had the opportunity to ask questions. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected. ☐

3. I understand that relevant sections of any of my medical notes may be looked at by Julie Whitney (the chief investigator) and Professor Jackson (research supervisor). I give permission for these individuals to have access to my records. ☐

4. I agree to my GP being informed of my participation in the study and if new medical problems are identified, to my GP being informed ☐

5. I agree to take part in the above study. ☐

6. When this research has been completed, I would like information on the results ☐

_____	_____	_____
Name of Patient	Date	Signature
_____	_____	_____
Name of Person taking consent (if different from researcher)	Date	Signature

I, the researcher have provided an explanation of the study to the participant and have answered any questions honestly and fully.

_____	_____	_____
Researcher	Date	Signature

When completed, 1 for participant; 1 for researcher site file; 1 (original) to be kept in medical notes

Figure 11.3 Consent form for participating in the screening study for those with capacity

Version 1
April 2009

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NHS Foundation Trust

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R&D Study Number: 07PM01

Consent for recording information from care records

Title of Project: Defining Falls Risk Factors in Older Adults

Name of Researcher: Julie Whitney

If you do not wish to take part in the full study, we would still like to collect some information about you and monitor you for any falls you may have over the next 6 months. We wish to do this because any information we can get about falls risk will be very useful.

Information such as your age, medical history, functional ability and any falls sustained over the next 6 months will be collected by the research team from care records or talking to carers.

The information will be put onto a computer database held at Kings College Hospital where it can only be accessed by the research team.

We will not record your name or your actual date of birth in this database so it would not be possible for you to be identified from the information we collect.
We will not identify you in any publications.

I agree to a member of the research team recording information about me to use in the above study.

_____	_____	_____
Name of Patient	Date	Signature

I, the researcher have provided an explanation of the study to the participant and have answered any questions honestly and fully.

_____	_____	_____
Researcher	Date	Signature

Figure 11.4 Information sheet for personal consultees of those without capacity
Version 5.
March 2009

King's College Hospital NHS
NHS Foundation Trust

Protocol reference number: 07/H0807/82

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Email: Julie.whitney@kch.nhs.uk

INFORMATION SHEET

Defining falls risk factors in older adults

We would like to invite _____ (the potential participant) to take part in the above research project.

Are you willing and able to act as a personal consultee for this person?

What will be required of me?

If you are willing and able to undertake this role, we will ask your advice about whether the person should take part in the study and what in your opinion their wishes and feelings about taking part in the study would be if they were able to consent for themselves.

We will provide you with information about this research project, in order that you can properly advise us as to what the person's wishes and feelings might be.

- Part 1 tells you the purpose of this study and what will happen to the potential participant if they take part.
- Part 2 gives you more detailed information about the conduct of the study.

Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you think the potential participant should take part.

PART 1

What is the purpose of the study?
To find out why older people with memory problems are more likely to fall.

Why has the person been invited to take part?

All residents living in this establishment will be invited to take part.

Do they have to take part?
No, it is up to you to decide. Remember to consider what the potential participant would have wanted to do if they could make the decision as well as what is in their best interests.
If you agree that the potential participant should take part, you will then be asked to sign a personal consultee form. You are still free to change your mind at any time after this and without giving a reason. This will not affect the standard of care the potential participant receives.

What will happen to the potential participant if you help to decide they should take part?

1. If you decide the potential participant should take part, a researcher (Julie Whitney) will come to see each participant to carry out several assessments. These assessments are usually spread out over 3 sessions on different days and include:

<u>Session 1</u>
A set of memory tests taking around 45 minutes
<u>Session 2</u>
Tests looking at vision, muscle strength, walking, balance, blood pressure and a medical examination taking around 60 minutes
<u>Session 3</u>
A further set of memory tests, some questions about your health and one balance test in total taking 45-60 minutes

2. Medical history and medication use will be taken from care records and medical notes.

3. Where possible, we will ask each participant if they would be willing to wear a small lightweight monitor attached to the leg to measure how much of the day is spent lying down, sitting or walking. This could be worn for up to 3 days.

4. After this we will then monitor the participant for 6 months to see whether they have any falls. They do not need to do anything from this point as the carers will record any falls and share this information with us.

We will only ask the participant to undertake the assessments they are capable of doing.

What are the risks and possible disadvantages of taking part?
There is a very small chance of injury due to falls or exacerbation of existing health problems during the physical assessment. However, this is unlikely as assessments will be carried out by a qualified and experienced researcher and are consistent with current clinical practice. There is a very small chance of discomfort caused by wearing the activity monitor. If this happens, the monitor can be removed immediately.

What are the possible benefits of taking part?
This study is unlikely to help the participant directly, but the information we get should help us to design treatment programmes to prevent falls in the future.
If we identify any new health problems during the research visits, we will contact the participant's GP.

What if there is a problem?
In the case of any complaints you can telephone: 020 3299 3420. Please read part 2 for more details

Will taking part in the study be kept confidential?
We will follow ethical and legal practice and all information about the participant will be handled in confidence. The details are included in part 2.

PART 2

What will happen if the potential participant doesn't want to carry on with the study or I feel they should not continue?
Participation in this study is entirely voluntary and any decision whether or not to participate will not impact on future health care.
If you decide that the potential participant should take part, you are still free to change your mind at any time.
If the participant decides not to continue, we will keep any data collected up to that point and continue to collect information from the care home about any falls for 6 months, unless otherwise requested.

What if there is a problem?
Complaints
If you have a concern about any aspect of this study, you should ask to speak with the researchers who will do their best to answer your questions. Telephone: 020 3299 3420.
If you remain unhappy and wish to complain formally, you can do this through the NHS Complaints Procedure. Details can be obtained from the hospital. Telephone: 020 3299 1760.

Harm
In the event that something does go wrong and the participant is harmed during the research study there are no special compensation arrangements. If the harm is due to someone's negligence then there may be grounds for a legal action for compensation against Kings College Hospital Foundation Trust but they may have to pay legal costs. The normal National Health Service complaints mechanisms will still be available.

Will taking part in the study be kept confidential?

All information which is collected during this research will be kept safely and nothing that would allow the participant to be identified personally will be published. The general practitioner will be informed of participation in the study.

What will happen to the results of the study?
The results will be written up for publication in journals as well as presented at conferences. We will provide you with information on the results if you request it. Presentations will be provided to staff in participating care homes. Individual participants will not be identified in any publication or presentation.

Who is organising and funding the research?
The research will be organised by Julie Whitney (chief investigator) at the Clinical Age Research Unit, Department of Clinical Gerontology, Kings College Hospital. The research has been funded by the British Geriatrics Society / Dunhill Medical Trust fellowship scheme. The project will be supervised by Professor Jackson, a consultant at Kings College Hospital.

Who has reviewed the study?
All research in the NHS is looked at by an independent group of people, called a research ethics committee to protect the participants' safety, rights, wellbeing and dignity. This study has been reviewed and given a favourable opinion by the South London and Maudsley and Institute of Psychiatry research ethics committee.

You will be given a copy of this information sheet and a signed personal consultee form to keep.
Thank you for taking the time to read through this information sheet.

Frequently asked questions

My relative / friend cannot walk. What will happen?
If your relative/friend is unable to stand up or walk, we would leave out all tests involving balance or walking.

My relative / friend would not be able to concentrate on the memory tests and questions. What will happen?
We will get as much information as we can from the carers as well as written information from care records and medical notes. We will not ask your relative / friend to undertake these tests or answer any questions

What will happen if my relative / friend gets distressed by memory testing?
The researcher will monitor the participant very closely for signs of discomfort or distress. If any distress is detected, the researcher will either offer the participant a rest, stop testing to resume another day or discontinue that particular test.

I will not be able to attend the assessment sessions. Will this be a problem?
There is no need for the personal consultee to attend the assessment sessions. You are welcome

Figure 11.5 General information about being a personal consultee
Version 1.
November 2007

King's College Hospital NHS
NHS Foundation Trust

Protocol reference number:
07/H0807/82

Clinical Age Research Unit
Department of Clinical Gerontology
King's College Hospital
Bessemer Road
London SE5 9RS

Direct tel: 020 3299 3420
Direct fax: 020 3299 3441
Email: Julie.whitney@kch.nhs.uk

Defining falls risk factors in older adults

Personal Consultee – Information and Guidance

What is a Personal Consultee?

In order to understand illness and disability, and to improve treatment and care, research is essential. That research may focus on the people with the illness or disability, and may invite those people to participate. Some people will have capacity to make their own decision whether to take part in the research.

Others, possibly those most affected by the illness or disability, may not have that capacity. They may not be able to understand enough of the research to be able to give informed consent. They may not be able to communicate a decision. The research provisions of the Mental Capacity Act are designed to allow such people to take part in research even though they cannot give valid consent of their own.

First, the research has to be approved by a Research Ethics Committee. Then, instead of asking the research participant for consent, the researcher must ask a consultee for an opinion whether the research participant would have wished to take part in the research.

Who can be a personal consultee?

Any person interested in the welfare of the proposed participant, for example:

- A family member, unpaid carer or friend
- A person acting under a Lasting Power of Attorney
- A court appointed deputy

Who cannot be a personal consultee?

- Paid carers and professionals
- People connected with the research (e.g. members of the research team)

Why have I been asked?

You have been asked to act as a personal consultee by a researcher because the researcher thinks you might be willing and able to do this because of your close relation with the proposed research participant.

If I agree to be a personal consultee, what will I have to do?

You will need to think about what the proposed participant's wishes and feelings about the research would be if they had capacity to make an informed decision and advise the researcher accordingly on whether in your view the person should be involved in the research or not. This means you need to

- Look at the information about the project that the researcher will provide for you.
- Think about whether or not the person would want to be involved in the research project if he or she had the capacity to make that decision.

You should not put forward your personal views on participation in the specific project or research in general, you must consider only what the person's views and interests are or would likely be. You should think about:

- What the broad aims of the research and the practicalities of taking part will mean for the proposed participant.
- How the specific activities in the research might impact the participant. For example, if the study involves activities in the afternoon when the person is most tired they might find it a strain or the research might involve an activity that the person particularly enjoys and thus would give them more pleasure.
- Any view previously expressed by the person on the overall nature of the research.

If you advise that the proposed participant would not have wanted to be involved in the research, the researcher cannot include them in the research.

If you advise that the proposed participant would want to be involved, they may be included in the research. If the research commences but the person shows any sign at any stage that they are not happy to be involved in the research you can change your advice at any time without giving a reason, whereby the researcher must withdraw the person from the research. If the person seems unhappy at any point or shows any signs of objection, then they will be withdrawn from the research.

The research project will have been approved beforehand by an NHS Research Ethics Committee and NHS Research and Development in the organisation where the research will take place. If you wish to see proof of approval from these bodies, please ask the researcher.

If you are concerned about any issues relating to the research and researcher and you do not feel that you are able to talk to the researcher about it, you can contact the following person/organisation for independent advice: The patient advice and liaison service Kings College Hospital on ***020 3299 3625****.*

I don't want to be a personal consultee- what do I do?

Tell the researcher and there is no further obligation. If you wish to suggest alternatives please do so.

Where can I get more information and guidance?

More information is available from:

Department for Constitutional Affairs (2007) *Mental Capacity Act 2005 Code of Practice* http://www.dca.gov.uk/legal-policy/mental-capacity/mca-cp.pdf

Department of Health (2007) *Guidance on nominating a consultee for research involving adults who lack capacity to consent* (consultation) http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_076207

Mental Capacity Implementation Programme (2007) *Making Decisions: a guide for family, friends and unpaid carers. Second edition* http://www.dca.gov.uk/legal-policy/mental-capacity/mibooklets/booklet02.pdf
A printed copy of this booklet is available by telephoning 023 80878038.

Printed copies of this information can be provided if necessary.

Julie Whitney

Researcher

Figure 11.6 Personal consultee advice form

King's College Hospital NHS
NHS Foundation Trust

Clinical Age Research Unit
King's College Hospital
Bessemer Road
London SE5 9RS

Direct tel: 020 3299 3420
Direct fax: 020 3299 3441
Email: Julie.whitney@kch.nhs.uk

R&D Study Number: 07PM01
Patient Identification Number for this trial:

Personal Consultee Approval Form

Title of Project: Defining Falls Risk Factors in Older Adults
Name of Researcher: Julie Whitney

Consultee please initial box

1. I am willing to act as a personal consultee for the proposed participant, and I am able to do this because _____ ☐

2. I have read the information sheet on personal consultees and the information sheet relating to the research project and have had the opportunity to ask questions. ☐

3. It is my belief that the proposed research participant would not object to being included in this research project. I am not aware of any previously expressed contrary opinion. ☐

4. I understand that if at any time I consider that the proposed research participant would object to being included in this research project, I can inform the researchers who will withdraw the person from the study immediately. ☐

5. I understand that any opinion I give will not affect the treatment and ongoing care the proposed research participant is receiving. ☐

6. I agree to the research participant's GP being informed of their participation in the study and if new medical problems are identified, to their GP being informed. ☐

_____ _____ _____
Name Date Signature

For the researcher:

1. I have explained the research project to the personal consultee and have answered all their questions honestly and fully.
2. I am not aware of any objection held by the proposed research participant to participate in this study (for example, an advance directive).
3. If at any time I am advised by the consultee that the proposed research participant would object to being included in this research project, I will withdraw the person from the study immediately.
4. If I become aware of any apparent resistance or objection from the proposed research participant I will withdraw them from the study immediately.

_____ _____ _____
Researcher Date Signature

When completed, 1 for representative; 1 for researcher site file; 1 (original) to be kept in medical notes

Figure 11.7 Other decision form

Version 3
April 2009

King's College Hospital NHS
NHS Foundation Trust

R&D Study Number: 07PM01

King's College Hospital NHS Foundation Trust
King's College Hospital
Denmark Hill
London SE5 9RS

Tel: 020 3299 9000
Fax: 020 3299 3445
Minicom: 020 3299 9009
www.kch.nhs.uk

Direct tel: 020 3299 3420
Direct fax: 020 3299 3441
Email: Julie.whitney@kch.nhs.uk

Other decision form

Title of Project: Defining Falls Risk Factors in Older Adults

Name of Researcher: Julie Whitney

If you have not signed the personal consultee approval form, please choose one of the options below and return this page in the pre-paid envelope.

1. **I do not wish to be a personal consultee** for _____

_____ _____ _____
Signed Date Print name

2. **I would like to suggest an alternative personal consultee**

Name_____ Relationship to proposed participant _____

Contact details_____

_____

3. After careful consideration, I have decided that _____ _____ **would not wish to take part in the study** entitled "Defining falls risk factors in older adults with cognitive impairment".

_____ _____ _____
Signed Date Print name

If you have decided that your relative / friend would not wish to take part in the study but would be happy for their care records to be examined by a member of the research team to collect information relevant to this study, please read and complete the form entitled "consent for recording information from care records".

Figure 11.8 Personal consultee advice for participating in the screening study only

Version 1
April 2009
Personal consultee version

King's College Hospital NHS
NHS Foundation Trust

King's College Hospital NHS Foundation Trust
King's College Hospital
Denmark Hill
London SE5 9RS

Tel: 020 3299 9000
Fax: 020 3299 3445
Minicom: 020 3299 9009
www.kch.nhs.uk

Direct tel: 020 3299 3420
Direct fax: 020 3299 3441
Email: Julie.whitney@kch.nhs.uk

R&D Study Number: 07PM01

Consent for recording information from care records

Title of Project: Defining Falls Risk Factors in Older Adults

Name of Researcher: Julie Whitney

It is important to understand why some people experience more falls than others in order to design an effective treatment programme to prevent falls.

To help with the study, information such as age, medical history, functional ability and any falls sustained over the next 6 months will be collected by the research team from care records or talking to carers.

The information will be put onto a computer database held at Kings College Hospital where it can only be accessed by the research team.

We will not record your relative / friend's name or actual date of birth in this database so it would not be possible for them to be identified from the information we collect. We will not identify them in any publications.

I agree to a member of the research team recording information about _____ to use in the above study.

_____ _____ _____
Name of personal consultee Date Signature

I, the researcher have provided an explanation of the study to the participant and have answered any questions honestly and fully.

_____ _____ _____
Researcher Date Signature

Figure 11.9 Nominated consultee information sheet
Version 5.
March 2009

King's College Hospital NHS
NHS Foundation Trust

Protocol reference number: 07/H0807/82

Clinical Age Research Unit
King's College Hospital
Bessemer Road
London SE5 9RS

Direct tel: 020 3299 3420
Direct fax: 020 3299 3441
Email: Julie.whitney@kch.nhs.uk

INFORMATION SHEET

Defining falls risk factors in older adults

We would like to invite _____ (the potential participant) to take part in the above research project.

Are you willing and able to act as a nominated consultee for this person?

What will be required of me?

If you are willing and able to undertake this role, we will ask your advice about whether the person should take part in the study and what in your opinion their wishes and feelings about taking part in the study would be if they were able to consent for themselves.

We will provide you with information about this research project, in order that you can properly advise us as to what the person's wishes and feelings might be.

- Part 1 tells you the purpose of this study and what will happen to the potential participant if they take part.
- Part 2 gives you more detailed information about the conduct of the study.

Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you think the potential participant should take part.

PART 1

What is the purpose of the study?
To find out why older people with memory problems are more likely to fall.

Why has the person been invited to take part?
All residents living in this establishment will be invited to take part.

Do they have to take part?
No, it is up to you to decide. Remember to consider what the potential participant would have wanted to do if they could make the decision as well as what is in their best interests.
If you agree that the potential participant should take part, you will then be asked to sign a nominated consultee form. You are still free to change your mind at any time after this and without giving a reason. This will not affect the standard of care the potential participant receives.

What will happen to the potential participant if you help to decide they should take part?

If you decide the potential participant should take part, a researcher (Julie Whitney) will come to see each participant to carry out several assessments. These assessments are usually spread out over 3 sessions on different days and include:

<u>Session 1</u>
A set of memory tests taking around 45 minutes
<u>Session 2</u>
Tests looking at vision, muscle strength, walking, balance, blood pressure and a medical examination taking around 60 minutes
<u>Session 3</u>
A further set of memory tests, some questions about your health and one balance test in total taking 45-60 minutes

- Medical history and medication use will be taken from care records and medical notes.

- Where possible, we will ask each participant if they would be willing to wear a small lightweight monitor attached to the leg to measure how much of the day is spent lying down, sitting or walking. This could be worn for up to 3 days.

- After this we will then monitor the participant for 6 months to see whether they have any falls. They do not need to do anything from this point as the carers will record any falls and share this information with us.

We will only ask the participant to undertake the assessments they are capable of doing.

What are the risks and possible disadvantages of taking part?
There is a very small chance of injury due to falls or exacerbation of existing health problems during the physical assessment. However, this is unlikely as assessments will be carried out by a qualified and experienced researcher and are consistent with current clinical practice. There is a very small chance of discomfort caused by

wearing the activity monitor. If this happens, the monitor can be removed immediately.

What are the possible benefits of taking part?
This study is unlikely to help the participant directly, but the information we get should help us to design treatment programmes to prevent falls in the future.
If we identify any new health problems during the research visits, we will contact the participant's GP.

What if there is a problem?
In the case of any complaints you can telephone: 020 3299 3420. Please read part 2 for more details

Will taking part in the study be kept confidential?
We will follow ethical and legal practice and all information about the participant will be handled in confidence. The details are included in part 2.

PART 2

What will happen if the potential participant doesn't want to carry on with the study or I feel they should not continue?
Participation in this study is entirely voluntary and any decision whether or not to participate will not impact on future health care.
If you decide that the potential participant should take part, you are still free to change your mind at any time.
If the participant decides not to continue, we will keep any data collected up to that point and continue to collect information from the care home about any falls for 6 months, unless otherwise requested.

What if there is a problem?
Complaints
If you have a concern about any aspect of this study, you should ask to speak with the researchers who will do their best to answer your questions. Telephone: 020 3299 3420.
If you remain unhappy and wish to complain formally, you can do this through the NHS Complaints Procedure. Details can be obtained from the hospital. Telephone: 020 3299 1760.

Harm
In the event that something does go wrong and the participant is harmed during the research study there are no special compensation arrangements. If the harm is due to someone's negligence then there may be grounds for a legal action for compensation against Kings College Hospital Foundation Trust but they may have to

pay legal costs. The normal National Health Service complaints mechanisms will still be available.

Will taking part in the study be kept confidential?
All information which is collected during this research will be kept safely and nothing that would allow the participant to be identified personally will be published. The general practitioner will be informed of participation in the study.

What will happen to the results of the study?
The results will be written up for publication in journals as well as presented at conferences. We will provide you with information on the results if you request it. Presentations will be provided to staff in participating care homes. Individual participants will not be identified in any publication or presentation.

Who is organising and funding the research?
The research will be organised by Julie Whitney (chief investigator) at the Clinical Age Research Unit, Department of Clinical Gerontology, Kings College Hospital. The research has been funded by the British Geriatrics Society / Dunhill Medical Trust fellowship scheme. The project will be supervised by Professor Jackson, a consultant at Kings College Hospital.

Who has reviewed the study?
All research in the NHS is looked at by an independent group of people, called a research ethics committee to protect the participants' safety, rights, wellbeing and dignity. This study has been reviewed and given a favourable opinion by the South London and Maudsley and Institute of Psychiatry research ethics committee.

You will be given a copy of this information sheet and a signed nomiated consultee form to keep.
Thank you for taking the time to read through this information sheet.

Figure 11.10 General information on what is a nominated consultee
Version 1.
April 2009

King's College Hospital NHS
NHS Foundation Trust

Protocol reference
number: 07/H0807/82

Clinical Age Research Unit
King's College Hospital
Bessemer Road
London SE5 9RS

Direct tel: 020 3299 3420
Direct fax: 020 3299 3441
Email: Julie.whitney@kch.nhs.uk

Nominated consultee – Information and Guidance

What is a nominated Consultee?

In order to understand illness and disability, and to improve treatment and care, research is essential. Some people will have capacity to make their own decision whether to take part in the research.

Others, possibly those most affected by illness or disability, may not have that capacity. They may not be able to understand enough of the research to be able to give informed consent. They may not be able to communicate a decision. The research provisions of the Mental Capacity Act are designed to allow such people to take part in research even though they cannot give valid consent of their own.

First, the research has to be approved by a Research Ethics Committee. Then, instead of asking the research participant for consent, the researcher must ask a consultee for an opinion whether the research participant would have wished to take part in the research. The first option is to use a personal consultee who could be a family member or friend. However, if a person has no relatives or friends willing to act in this role, a nominated consultee can be used.

Who can be a nominated consultee?

Any person interested in the welfare of the proposed participant, for example:

- A professional carer or nurse
- A care manager
- The person's doctor

Who cannot be a nominated consultee?

- People connected with the research (e.g. members of the research team)

Why have I been asked?

You have been asked to act as a nominated consultee by the researcher because you are involved in the proposed participant's care.

If I agree to be a nominated consultee, what will I have to do?

You will need to think about what the proposed participant's wishes and feelings about the research would be if they had capacity to make an informed decision and advise the researcher accordingly on whether in your view the person should be involved in the research or not. This means you need to

- Look at the information about the project that the researcher will provide for you.
- Think about whether or not the person would want to be involved in the research project if he or she had the capacity to make that decision.

You should not put forward your personal views on participation in the specific project or research in general, you must consider only what the person's views and interests are or would likely be. You should think about:

- What the broad aims of the research and the practicalities of taking part will mean for the proposed participant.
- How the specific activities in the research might impact the participant. For example, if the study involves activities in the afternoon when the person is most tired they might find it a strain or the research might involve an activity that the person particularly enjoys and thus would give them more pleasure.
- Any view previously expressed by the person on the overall nature of the research.

If you advise that the proposed participant would not have wanted to be involved in the research, the researcher cannot include them in the research.

If you advise that the proposed participant would want to be involved, they may be included in the research. If the research commences but the person shows any sign at any stage that they are not happy to be involved in the research you can change your advice at any time without giving a reason, whereby the researcher must withdraw the person from the research. If the person seems unhappy at any point or shows any signs of objection, then they will be withdrawn from the research.

The research project will have been approved beforehand by an NHS Research Ethics Committee and NHS Research and Development in the organisation where the research will take place. If you wish to see proof of approval from these bodies, please ask the researcher.

If you are concerned about any issues relating to the research and researcher and you do not feel that you are able to talk to the researcher about it, you can contact the following person/organisation for independent advice: The patient advice and liaison service Kings College Hospital on ***020 3299 3625****.*

I don't want to be a nominated consultee- what do I do?

Tell the researcher and there is no further obligation. If you wish to suggest alternatives please do so.

Where can I get more information and guidance?

More information is available from:

- Department for Constitutional Affairs (2007) *Mental Capacity Act 2005 Code of Practice* http://www.dca.gov.uk/legal-policy/mental-capacity/mca-cp.pdf
- Department of Health (2007) *Guidance on nominating a consultee for research involving adults who lack capacity to consent* (consultation) http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_076207
- Mental Capacity Implementation Programme (2007) *Making Decisions: a guide for family, friends and unpaid carers. Second edition* http://www.dca.gov.uk/legal-policy/mental-capacity/mibooklets/booklet02.pdf

A printed copy of this booklet is available by telephoning 023 80878038.

Printed copies of this information can be provided if necessary.

Figure 11.11 Nominated consultee advice form

King's College Hospital NHS
NHS Foundation Trust

Clinical Age Research Unit
King's College Hospital
Bessemer Road
London SE5 9RS

Direct tel: 020 3299 3420
Direct fax: 020 3299 3441
Email: Julie.whitney@kch.nhs.uk

R&D Study Number: 07PM01
Patient Identification Number for this trial:

Nominated Consultee Approval Form

Title of Project: Defining Falls Risk Factors in Older Adults
Name of Researcher: Julie Whitney

Consultee please initial box

1. I am willing to act as a nominated consultee for the proposed participant, and I am able to do this because I am the person's carer / care manager ☐

2. I have read the information sheet on nominated consultees and the information sheet relating to the research project and have had the opportunity to ask questions. ☐

3. It is my belief that the proposed research participant would not object to being included in this research project. I am not aware of any previously expressed contrary opinion. ☐

4. I understand that if at any time I consider that the proposed research participant would object to being included in this research project, I can inform the researchers who will withdraw the person from the study immediately. ☐

5. I understand that any opinion I give will not affect the treatment and ongoing care the proposed research participant is receiving. ☐

6. I agree to the research participant's GP being informed of their participation in the study and if new medical problems are identified, to their GP being informed. ☐

_____	_____	_____
Name	Date	Signature

For the researcher:

1. I have explained the research project to the nominated consultee and have answered all their questions honestly and fully.
2. I am not aware of any objection held by the nominated research participant to participate in this study (for example, an advance directive).
3. If at any time I am advised by the consultee that the proposed research participant would object to being included in this research project, I will withdraw the person from the study immediately.
4. If I become aware of any apparent resistance or objection from the proposed research participant I will withdraw them from the study immediately.

_____	_____	_____
Researcher	Date	Signature

Figure 11.12 Nominated consultee advice form for participating in the screening study only

Version 1
April 2009
Nominated consultee version

King's College Hospital NHS
NHS Foundation Trust

King's College Hospital NHS Foundation Trust
King's College Hospital
Denmark Hill
London SE5 9RS

Tel: 020 3299 9000
Fax: 020 3299 3445
Minicom: 020 3299 9009
www.kch.nhs.uk

Direct tel: 020 3299 3420
Direct fax: 020 3299 3441
Email: Julie.whitney@kch.nhs.uk

R&D Study Number: 07PM01

Consent for recording information from care records

Title of Project: Defining Falls Risk Factors in Older Adults

Name of Researcher: Julie Whitney

If you do not think the proposed participant would wish to take part in the full study, we would still like to collect some information about them and monitor them for any falls they may have over the next 6 months. We wish to do this because any information we can get about falls risk will be very useful to the outcome of this research project.

Information such as age, medical history, functional ability and any falls sustained over the next 6 months will be collected by the research team from care records or talking to carers.

The information will be put onto a computer database held at Kings College Hospital where it can only be accessed by the research team.

We will not record the proposed participant's name or actual date of birth in this database so it would not be possible for them to be identified from the information we collect. We will not identify them in any publications.

I agree to a member of the research team recording information about _____ to use in the above study.

_____ _____ _____
Name of nominated consultee Date Signature

I, the researcher have provided an explanation of the study to the participant and have answered any questions honestly and fully.

_____ _____ _____
Researcher Date Signature

12 Appendix C: Assessment tools

Figure 12.1 Barthel scale

THE Patient Name: _____
BARTHEL Rater Name: _____
INDEX Date: _____
Activity Score

FEEDING
0 = unable
5 = needs help cutting, spreading butter, etc., or requires modified diet
10 = independent _____
BATHING
0 = dependent
5 = independent (or in shower) _____
GROOMING
0 = needs to help with personal care
5 = independent face/hair/teeth/shaving (implements provided) _____
DRESSING
0 = dependent
5 = needs help but can do about half unaided
10 = independent (including buttons, zips, laces, etc.) _____
BOWELS
0 = incontinent (or needs to be given enemas)
5 = occasional accident
10 = continent _____
BLADDER
0 = incontinent, or catheterized and unable to manage alone
5 = occasional accident
10 = continent _____
TOILET USE
0 = dependent
5 = needs some help, but can do something alone
10 = independent (on and off, dressing, wiping) _____
TRANSFERS (BED TO CHAIR AND BACK)
0 = unable, no sitting balance
5 = major help (one or two people, physical), can sit
10 = minor help (verbal or physical)
15 = independent _____
MOBILITY (ON LEVEL SURFACES)
0 = immobile or < 50 yards
5 = wheelchair independent, including corners, > 50 yards
10 = walks with help of one person (verbal or physical) > 50 yards
15 = independent (but may use any aid; for example, stick) > 50 yards _____
STAIRS
0 = unable
5 = needs help (verbal, physical, carrying aid)
10 = independent _____
TOTAL (0–100): _____

Figure 12.2 Goldberg Anxiety Scale

If score >2 on questions 1-4 then continue to ask questions 5-9. If score <2 on questions 1-4, stop at question 4

1. Have you felt keyed up, high strung or on edge?
2. Have you been worrying a lot?
3. Have you been irritable?
4. Have you had any difficulty relaxing?

5. Have you been sleeping poorly?
6. Have you had headaches or neck-aches?
7. Have you had any of the following: trembling, tingling, dizzy spells, sweating, frequent urination, or diarrhea?
8. Have you been worried about your health
9. Have you had difficulty falling asleep?

Figure 12.3 Geriatric depression scale

Geriatric Depression Scale: Short Form

Choose the best answer for how you have felt over the past week:

1. Are you basically satisfied with your life? YES / **NO**
2. Have you dropped many of your activities and interests? **YES** / NO
3. Do you feel that your life is empty? **YES** / NO
4. Do you often get bored? **YES** / NO
5. Are you in good spirits most of the time? YES / **NO**
6. Are you afraid that something bad is going to happen to you? **YES** / NO
7. Do you feel happy most of the time? YES / **NO**
8. Do you often feel helpless? **YES** / NO
9. Do you prefer to stay at home, rather than going out and doing new things? **YES** / NO
10. Do you feel you have more problems with memory than most? **YES** / NO
11. Do you think it is wonderful to be alive now? YES / **NO**
12. Do you feel pretty worthless the way you are now? **YES** / NO
13. Do you feel full of energy? YES / **NO**
14. Do you feel that your situation is hopeless? **YES** / NO
15. Do you think that most people are better off than you are? **YES** / NO

Answers in **bold** indicate depression. Score 1 point for each bolded answer.

Figure 12.4 Neuropsychiatric inventory

Name of patient: _____ Date: _____

Informant: Spouse: _____ Child: _____ Other: _____

Please answer the following questions based on *changes* that have occurred since the patient first began to experience memory problems.

Circle "yes" only if the symptom has been present in the *past month*. Otherwise, circle "no".

For each item marked "yes":

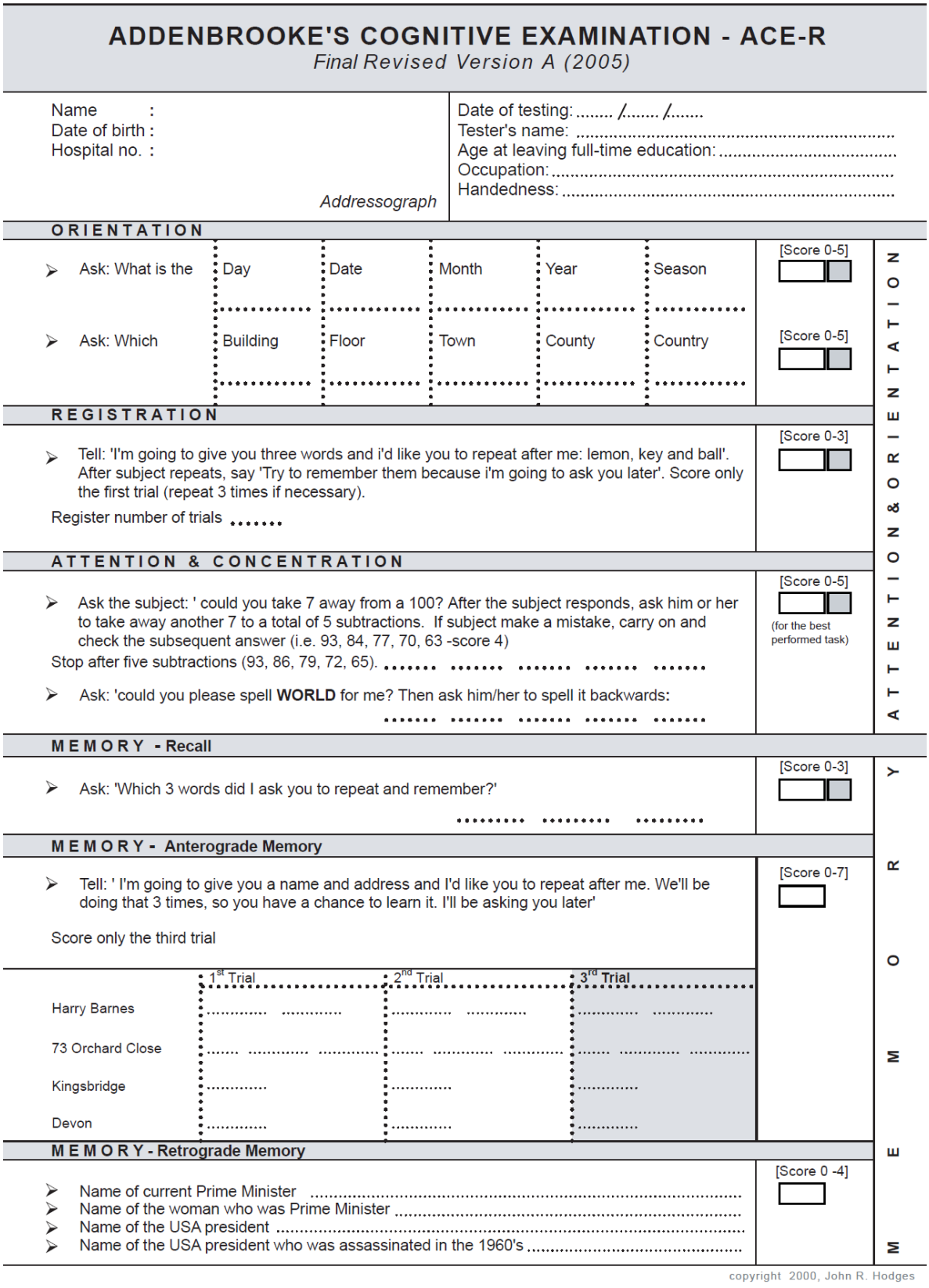
Rate the *severity* of the symptom (how it affects the patient):
1 = Mild (noticeable, but not a significant change)
2 = Moderate (significant, but not a dramatic change)
3 = Severe (very marked or prominent; a dramatic change)

Rate the *distress* you experience because of that symptom (how it affects you):
0 = Not distressing at all
1 = Minimal (slightly distressing, not a problem to cope with)
2 = Mild (not very distressing, generally easy to cope with)
3 = Moderate (fairly distressing, not always easy to cope with)
4 = Severe (very distressing, difficult to cope with)
5 = Extreme or very severe (extremely distressing, unable to cope with)

Please answer each question honestly and carefully. Ask for assistance if you are not sure how to answer any question.

Delusions		Does the patient believe that others are stealing from him or her, or planning to harm him or her in some way?									
Yes	No	Severity:	1	2	3	Distress:	0	1	2	3	4	5
Hallucinations		Does the patient act as if he or she hears voices? Does he or she talk to people who are not there?									
Yes	No	Severity:	1	2	3	Distress:	0	1	2	3	4	5
Agitation or aggression		Is the patient stubborn and resistive to help from others?									
Yes	No	Severity:	1	2	3	Distress:	0	1	2	3	4	5
Depression or dysphoria		Does the patient act as if he or she is sad or in low spirits? Does he or she cry?									
Yes	No	Severity:	1	2	3	Distress:	0	1	2	3	4	5
Anxiety		Does the patient become upset when separated from you? Does he or she have any other signs of nervousness, such as shortness of breath, sighing, being unable to relax, or feeling excessively tense?									
Yes	No	Severity:	1	2	3	Distress:	0	1	2	3	4	5
Elation or euphoria		Does the patient appear to feel too good or act excessively happy?									
Yes	No	Severity:	1	2	3	Distress:	0	1	2	3	4	5
Apathy or indifference		Does the patient seem less interested in his or her usual activities and in the activities and plans of others?									
Yes	No	Severity:	1	2	3	Distress:	0	1	2	3	4	5
Disinhibition		Does the patient seem to act impulsively? For example, does the patient talk to strangers as if he or she knows them, or does the patient say things that may hurt people's feelings?									
Yes	No	Severity:	1	2	3	Distress:	0	1	2	3	4	5
Irritability or lability		Is the patient impatient and cranky? Does he or she have difficulty coping with delays or waiting for planned activities?									
Yes	No	Severity:	1	2	3	Distress:	0	1	2	3	4	5
Motor disturbance		Does the patient engage in repetitive activities, such as pacing around the house, handling buttons, wrapping string, or doing other things repeatedly?									
Yes	No	Severity:	1	2	3	Distress:	0	1	2	3	4	5
Nighttime behaviors		Does the patient awaken you during the night, rise too early in the morning, or take excessive naps during the day?									
Yes	No	Severity:	1	2	3	Distress:	0	1	2	3	4	5
Appetite and eating		Has the patient lost or gained weight, or had a change in the food he or she likes?									
Yes	No	Severity:	1	2	3	Distress:	0	1	2	3	4	5

Figure 12.5 Addenbrooke's Cognitive examination (ACE-R)



ADDENBROOKE'S COGNITIVE EXAMINATION - ACE-R

Final Revised Version A (2005)

Name :
Date of birth :
Hospital no. :

Addressograph

Date of testing: ..... /..... /.....
Tester's name: .....
Age at leaving full-time education: .....
Occupation: .....
Handedness: .....

ORIENTATION — ATTENTION & ORIENTATION

➢ Ask: What is the	Day	Date	Month	Year	Season	[Score 0-5]
➢ Ask: Which	Building	Floor	Town	County	Country	[Score 0-5]

REGISTRATION — ATTENTION & ORIENTATION

➢ Tell: 'I'm going to give you three words and i'd like you to repeat after me: lemon, key and ball'. After subject repeats, say 'Try to remember them because i'm going to ask you later'. Score only the first trial (repeat 3 times if necessary).

Register number of trials .....

[Score 0-3]

ATTENTION & CONCENTRATION — ATTENTION & ORIENTATION

➢ Ask the subject: ' could you take 7 away from a 100? After the subject responds, ask him or her to take away another 7 to a total of 5 subtractions. If subject make a mistake, carry on and check the subsequent answer (i.e. 93, 84, 77, 70, 63 -score 4)

Stop after five subtractions (93, 86, 79, 72, 65). ....

➢ Ask: 'could you please spell **WORLD** for me? Then ask him/her to spell it backwards:

....

[Score 0-5] (for the best performed task)

MEMORY - Recall — MEMORY

➢ Ask: 'Which 3 words did I ask you to repeat and remember?'

....

[Score 0-3]

MEMORY - Anterograde Memory — MEMORY

➢ Tell: ' I'm going to give you a name and address and I'd like you to repeat after me. We'll be doing that 3 times, so you have a chance to learn it. I'll be asking you later'

Score only the third trial

[Score 0-7]

	1st Trial	2nd Trial	3rd Trial
Harry Barnes	....	....	....
73 Orchard Close	....	....	....
Kingsbridge	.....	.....	.....
Devon	.....	.....	.....

MEMORY - Retrograde Memory — MEMORY

➢ Name of current Prime Minister .....
➢ Name of the woman who was Prime Minister .....
➢ Name of the USA president .....
➢ Name of the USA president who was assassinated in the 1960's .....

[Score 0 -4]

VERBAL FLUENCY - Letter 'P' and animals

➢ **Letters**

Say: 'I'm going to give you a letter of the alphabet and I'd like you to generate as many words as you can beginning with that letter, but not names of people or places. Are you ready? You've got a minute and the letter is P'

[Score 0 - 7] ☐

>17	7
14-17	6
11-13	5
8-10	4
6-7	3
4-5	2
2-3	1
<2	0
total	correct

➢ **Animals**

Say: 'Now can you name as many animals as possible, beginning with any letter?

[Score 0 - 7] ☐

>21	7
17-21	6
14-16	5
11-13	4
9-10	3
7-8	2
5-6	1
<5	0
total	correct

FLUENCY

LANGUAGE - Comprehension

➢ Show written instruction:

[Score 0-1] ☐ ☐

Close your eyes

➢ 3 stage command:
'Take the paper in your right hand. Fold the paper in half. Put the paper on the floor'

[Score 0-3] ☐ ☐

LANGUAGE - Writing

➢ Ask the subject to make up a sentence and write it in the space below:
Score 1 if sentence contains a subject and a verb (see guide for examples)

[Score 0-1] ☐ ☐

LANGUAGE

LANGUAGE - Repetition

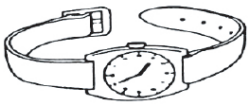
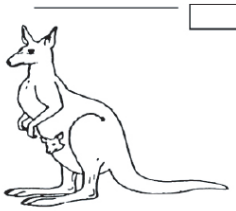
➢ Ask the subject to repeat:**' hippopotamus'; 'eccentricity; 'unintelligible'; 'statistician'**
Score 2 if all correct; 1 if 3 correct; 0 if 2 or less. [Score 0-2]

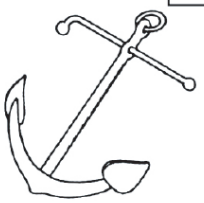
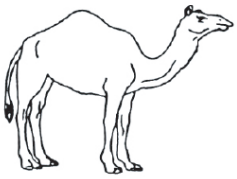
➢ Ask the subject to repeat: **'Above, beyond and below'** [Score 0-1]

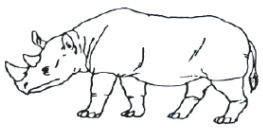
➢ Ask the subject to repeat: **'No ifs, ands or buts'** [Score 0-1]

LANGUAGE - Naming

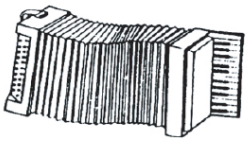
➢ Ask the subject to name the following pictures: [Score 0-2] pencil + watch







[Score 0-10]

LANGUAGE - Comprehension

➢ Using the pictures above, ask the subject to: [Score 0-4]

- Point to the one which is associated with the monarchy _____
- Point to the one which is a marsupial _____
- Point to the one which is found in the Antarctic _____
- Point to the one which has a nautical connection _____

LANGUAGE

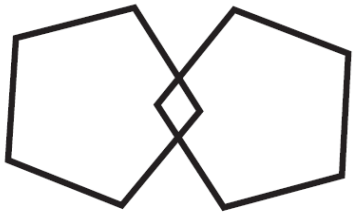
LANGUAGE - Reading

➢ Ask the subject to read the following words: [Score 1 only if all correct] [Score 0-1] ☐

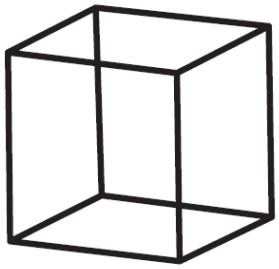
sew
pint
soot
dough
height

VISUOSPATIAL ABILITIES

➢ Overlapping pentagons: Ask the subject to copy this diagram: [Score 0-1] ☐ ☐



➢ Wire cube : Ask the subject to copy this drawing (for scoring, see instructions guide) [Score 0-2] ☐



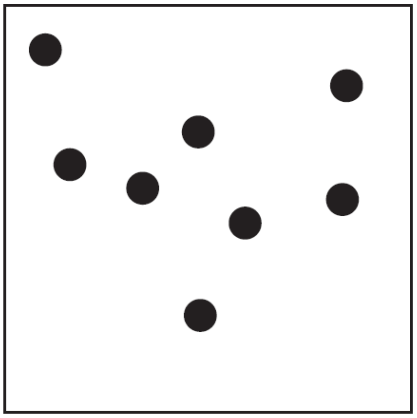
➢ Clock: Ask the subject to draw a clock face with numbers and the hands at ten past five. (for scoring see instruction guide: circle = 1, numbers = 2, hands = 2 if all correct) [Score 0-5] ☐

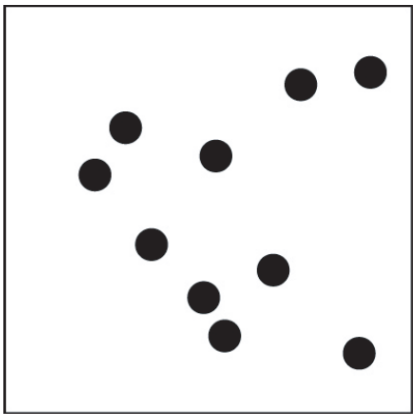
PERCEPTUAL ABILITIES

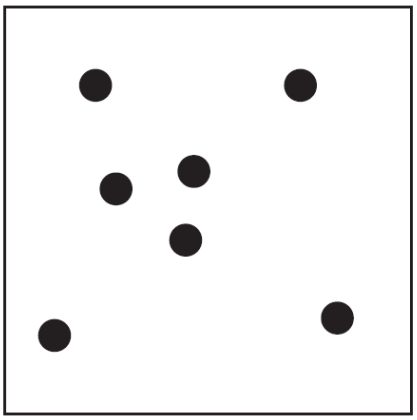
VISUOSPATIAL

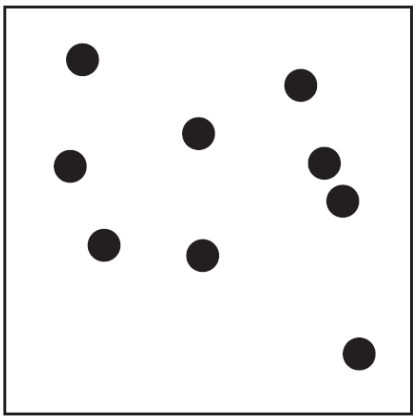
➢ Ask the subject to count the dots without pointing them

[Score 0-4]







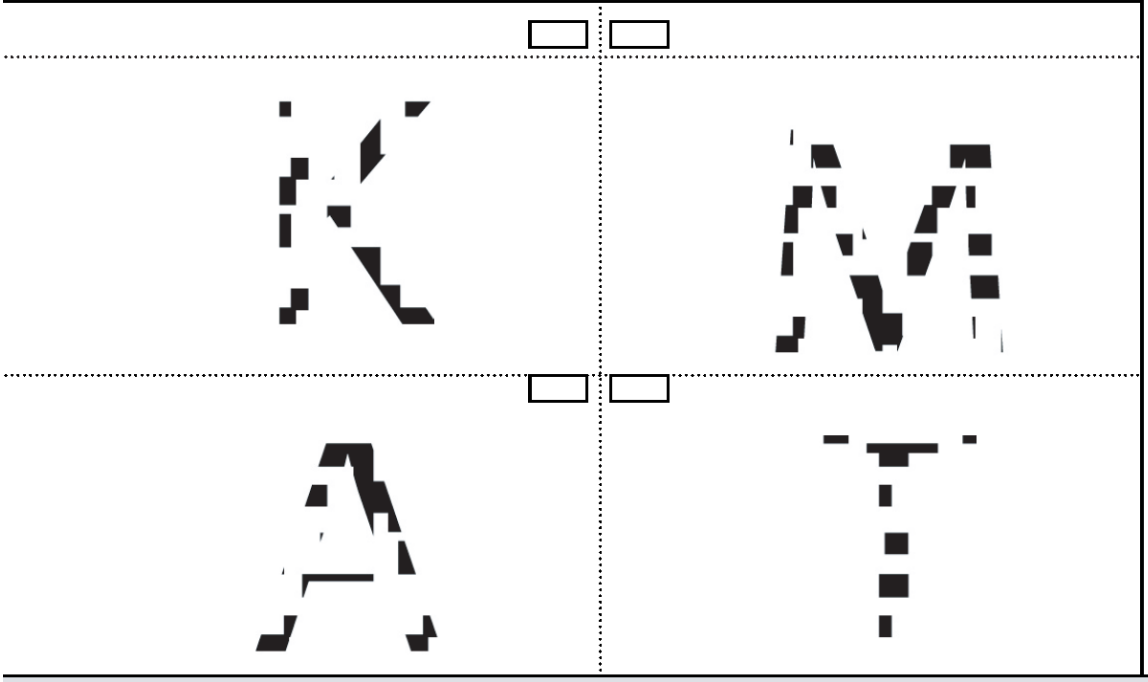


ADDENBROOKE'S COGNITIVE EXAMINATION - ACE-R

Final Revised Version A (2005)

PERCEPTUAL ABILITIES

➢ Ask the subject to identify the letters [Score 0-4]



RECALL

➢ Ask "Now tell me what you remember of that name and address we were repeating at the beginning"

	Harry	Barnes	....
73	Orchard	Close	....
	Kingsbridge		.....
	Devon		.....

[Score 0-7]

RECOGNITION

➢ This test should be done if subject failed to recall one or more items. If all items were recalled, skip the test and score 5. If only part is recalled start by ticking items recalled in the shadowed column on the right hand side. Then test not recalled items by telling "ok, I'll give you some hints: was the name X, Y or Z?" and so on. Each recognised item scores one point which is added to the point gained by recalling.

[Score 0-5]

Jerry Barnes		Harry Barnes		Harry Bradford		recalled	
37		73		76		recalled	
Orchard Place		Oak Close		Orchard Close		recalled	
Oakhampton		Kingsbridge		Dartington		recalled	
Devon		Dorset		Somerset		recalled	

General Scores

MMSE	/30
ACE-R	/100

Subscores

Attention and Orientation	/18
Memory	/26
Fluency	/14
Language	/26
Visuospatial	/16

VISUOSPATIAL MEMORY SCORE

Normative values based on 63 controls aged 52-75 and 142 dementia patients aged 46-86

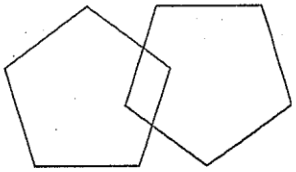
Cut-off <88 gives 94% senstivity and 89% specificity for dementia
Cut-off <82 gives 84% sensitivity and 100% specificity for dementia

Figure 12.6 Mini Mental State Examination

The Mini-Mental State Exam

Patient_____ _____ _____ Examiner _____ _____ Date_____

Maximum	Score	
		Orientation
5	( )	What is the (year) (season) (date) (day) (month)?
5	( )	Where are we (state) (country) (town) (hospital) (floor)?
		Registration
3	( )	Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them. Give 1 point for each correct answer. Then repeat them until he/she learns all 3. Count trials and record. Trials _____
		Attention and Calculation
5	( )	Serial 7's. 1 point for each correct answer. Stop after 5 answers. Alternatively spell "world" backward.
		Recall
3	( )	Ask for the 3 objects repeated above. Give 1 point for each correct answer.
		Language
2	( )	Name a pencil and watch.
1	( )	Repeat the following "No ifs, ands, or buts"
3	( )	Follow a 3-stage command: "Take a paper in your hand, fold it in half, and put it on the floor."
1	( )	Read and obey the following: CLOSE YOUR EYES
1	( )	Write a sentence.
1	( )	Copy the design shown.



____ Total Score

Figure 12.7 Environment checklist

Individual Environmental Checklist Section A	Surname: . . . . . . First Name/s: . . . . . . U.R. No . . . . . . Date of Birth: / / *(Please affix Patient ID label here if available)*

Bedrooms / Ward — Please tick appropriate box	Yes	No	N/A
• Is the bed at the lowest height for safety of client (ie. so they can sit and touch the floor with their feet, with their legs at 90 degrees)?			
• Are there call bells within easy reach of client?			
• Is the mattress firm to provide support when moving in the bed?			
• Do patients have bedside lockers or tables that they can put things on safely without undue stretching and twisting?			
• Is there space for client to store any walking aids where they can reach them without getting out of bed?			
• Do the beds have locks on castors which work easily and effectively?			
• Do patients have easy access to night-lights?			
• Is the room free of clutter?			
• Is the room free of cords and other hazards on the floor?			
• Is the room free of loose rugs on the floor?			
Furniture — Please tick appropriate box	**Yes**	**No**	**N/A**
• Are chairs correct height (ie. allow the patient to have feet on ground and legs at 90 degree angle)?			
• Do chairs have sturdy armrests to assist patient getting in and out of them?			
• Is the height of chairs adjustable to cater for people of different sizes?			
• Are chair legs straight rather than sticking out and being a hazard?			
• Are the pieces of furniture secure enough to support a patient, should they lean upon them or grab them if they lose their balance?			
• Can the patient rise/sit with ease?			
• Can the patient safely move the footstool before transferring?			
• Can the patient reach the footstool when required?			
Mobility Aids — Please tick appropriate box	**Yes**	**No**	**N/A**
• Brakes on wheelie frames and wheelchair are in good working order.			
• Appropriate height for client.			
• Aid is kept within easy reach.			
• Footplates of wheelchair are easy to move.			
• Patient has been educated regarding safety with aid (walker / wheelchair).			